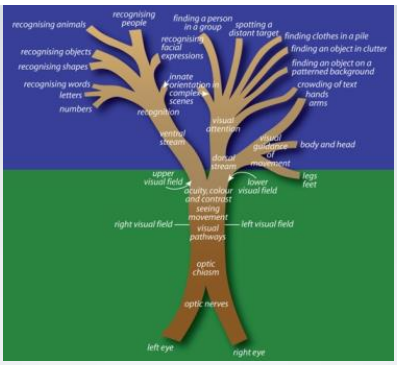


VISION IN ACTION: A VISUAL-SPATIAL PERSPECTIVE FOR PERCEPTUAL-MOTOR LEARNING

KATIE DAVIS, OD, FCOVD

1

WHAT IS THE PURPOSE OF HAVING A VISUAL SYSTEM?

2

"A dynamic, interactive process of motor and sensory function mediated by the eyes for the purpose of simultaneous organization of posture, movement, spatial orientation, manipulation of the environment and to its highest degree of perception and thought."

William Padula, OD, FCOVD, FNORA

3

THE THREE O'S

OPTICIAN, OPHTHALMOLOGIST, OPTOMETRIST

4

THE THREE O'S: *OPTICIAN*

- Fills prescription for glasses and contact lenses
- Frame and Lens Specialists
- What prescription is best in which frame
  - Lightest and Thinnest Lenses
  - Best Clarity and Optics

5

THE THREE O'S: *OPHTHALMOLOGIST*

- Important for Eyesight Threatening Problems
- Concerned with Structure of the eye
- Assess for eye diseases to ensure ocular health
  - Cataracts, Glaucoma, Red Eyes, Diabetes, Retinal tears, Blunt Trauma, Macular Degeneration, etc
- Surgery of eye structures

6

THE THREE O'S: *OPHTHALMOLOGIST*

- Pediatric Ophthalmologist
- Concerned with Structure of the eye
- Assess for eye diseases to ensure ocular health
- *Surgery of eye the eye muscles, patching of the eyes, and glasses*
- Use the cover test and depth perception as the only measure of visual function
- Does not assess for tracking, visual skills over time, or visual information processing skills

7

THE THREE O'S: *OPTOMETRIST*

- Primary Care Eye Doctor
- Concerned with how you use your eyesight in every day life
- Prescribes glasses or contact lenses to correct eyesight
- Assess for eye diseases to ensure ocular health
  - Cataracts, Glaucoma, Red Eyes, Diabetes, Macular Degeneration, etc
- Refers for surgery or vision therapy

8

FROM THE AMERICAN OPTOMETRIC ASSOCIATION

Box 2: Comprehensive Eye Health and Vision Evaluation

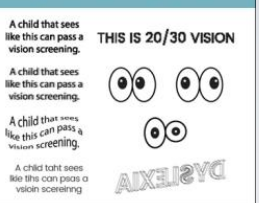
1. Ocular Health Evaluation
   a. Anterior segment evaluation
   b. Pupillary response
   c. Posterior segment evaluation
   d. Visual field
   e. Intraocular eye pressure
2. Refractive Status
   a. Retinoscopy and Manifest Refraction
      i. Amblyogenic risk factors
         - Isometric (Hyperopia:>+5.00, Myopia:>-8.00, Astigmatism:>-2.50)
         - Anisometric (Hyperopia: >+1.00, Myopia:>-3.00 Astigmatism:>-1.50)
3. Binocular Status-Strabismic vs. Non-Strabismic
   a. Unilateral cover test to diagnose strabismic deviations (ET, XT, HyperT, HypoT)
   b. Alternating cover test to diagnose non-strabismic deviations (EP, XP, HyperP, HypoP)
4. Sensory Fusion Evaluation
   a. Suppression
      i. Worth 4 Dot
      ii. Vecto Targets
   b. Anomalous Correspondance
      i. Worth 4 Dot with unilateral cover test
      ii. Bagolini Lenses
      iii. Maddox Rod
5. Motor Fusion
   i. Vergence Ranges at Distance and Near-Base In, Base Out, Base Up, and Base Down
6. Stereopsis-Distance and Near
7. Accommodation
   i. Accommodative Amplitudes OD, OS
   ii. Negative Relative Accommodation (NRA)
   iii. Positive Relative Accommodation (PRA)
   iv. +2.00/-2.00 Accommodative Flipper Facility Testing
   v. Monocular Estimation Method (MEM)/Fused Cross Cylinder (FCC)
8.) Oculomotor Testing
   i. Saccades
   ii. Pursuits

From Cooper, J., Burns, C., Cotter, S., Daum, K., Griffin, J., & Scheiman, M. Optometric Practice Guideline *Care of the Patient with Accommodative and Vergence Dysfunction* (18th ed.). St. Louis, MO: American Optometric Association; 2011:50-57.
Rouse M, Cooper J, Cotter S, Press L, Tannen B. Optometric Clinical Practice Guideline Care of the Patient with Amblyopia. *American Optometric Association*. 2004: 1-54.

9

20/20 VISION IS **NOT** ENOUGH

A vision test **does not** test:
- A Child's focusing ability -
- Tracking -
- Visual perception skills -



Many children **pass** their annual school vision screening, or the pediatrician's eye chart, but **remain undiagnosed** with problems of the visual system.
So, is it any wonder why your child can't sit still for 20 minutes to do homework?

10

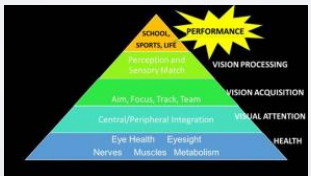
THE THREE O'S: *DEVELOPMENTAL OPTOMETRIST*

- "FCOVD" Fellow of the Optometrist in Vision Development
- Specialty trained to address functional visual needs and visual processing
- Vision care provided by all COVD members is based on the principle that vision can be developed and changed…we are not born with fully developed visual abilities and good vision is developed through a learned process.

11

THE DEVELOPMENTAL VISION EVALUATION

- Are the patient's visual needs being met?
- Consult with patients and other professionals as to ways to address any mismatch optometric or otherwise.



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THE DEVELOPMENTAL VISION EVALUATION

1. Extensive Case History
2. Visual Acuity (D & N)
3. Dynamic Visual Acuity
4. Ocular health exam
5. Refraction
6. Visual Field assessment
7. Cover test (D & N)
8. Sensory fusion (Worth 4 Dot)

14

THE DEVELOPMENTAL VISION EVALUATION

9. Near Point of Convergence
10. Red lens near point of convergence
11. Comfort point of convergence
12. Stereopsis (Depth Perception)
13. Vergence Ranges (D & N)
14. Standardized oculomotor testing (DEM or KD Test)
15. Infrared Eye Movement Testing
16. Free space pursuits and saccades
17. Accommodative Abilities

15

THE DEVELOPMENTAL VISION EVALUATION

17. Visual information processing
    - Motor-Free Visual Perceptual Test, Third Edition (MVPT-3)
    - The Test of Visual Perceptual Skills, Third Edition (TVPS-3)
18. Visual motor integration
    - Beery VMI
    - Motor Speed/Motor Precision
19. Gross motor and/or primitive reflex screening

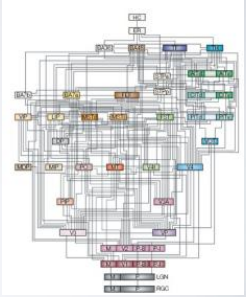
16

THE DEVELOPMENTAL VISION EVALUATION

17

THE VISUAL SYSTEM- AN OVERVIEW

- Optic Nerve: 1,000,000 nerve fibers per eye
- 2/3rd of all sensory processing in the entire body is directly affected by information coming from the two eyes
- Every lobe of the cerebral cortex is involved in processing visual information
- There is more area of the brain dedicated to processing visual information than ALL of the other sensory modalities combined!



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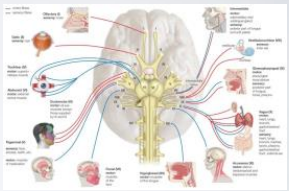
CRANIAL NERVES INVOLVED WITH VISION

- CN II, Optic Nerve
- CN III, Oculomotor (moves eyes/constrict pupil/accommodate)
- CN IV, Trochlear (moves eye up)
- CN V, Trigeminal (corneal sensitivity, maintaining the tear film)
- CN VI, Abducens (moves eye out)
- CN VII, Facial (closes eyelid)
- CN VIII, Vestibulocochlear (VOR)
- CN XI, Accessory (VOR)



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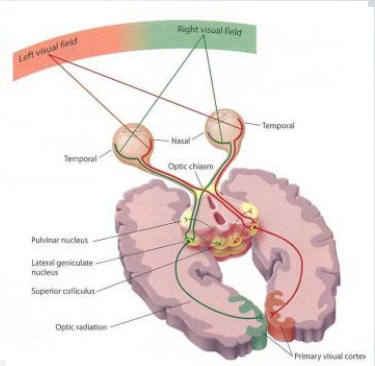
THE SIGHT PATHWAY

- Retina
- Optic Nerve
- **Optic Chiasm**
- Optic Tract
- Optic Radiations
- Occipital Lobes



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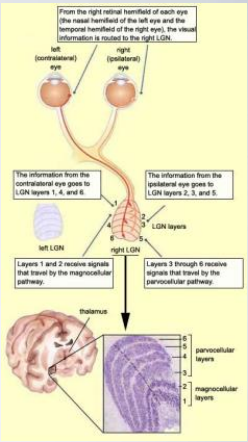
LATERAL GENICULATE NUCLEUS

- Diencephalon
  - Thalamus
    - Lateral Geniculate Nucleus – LGN
      - The LGN is the relay point for 80% of the information that goes from the eyes to visual areas of the brain
      - **Yet at least 80% of the input TO the LGN comes from sources other than the eyes**



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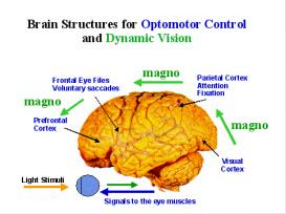
"EYES DON'T TELL BRAINS WHAT TO SEE; BRAINS TELL EYES WHAT TO LOOK FOR"

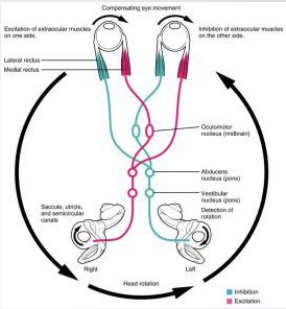
Dr. Lawrence Macdonald



22

VESTIBULAR PATHWAY

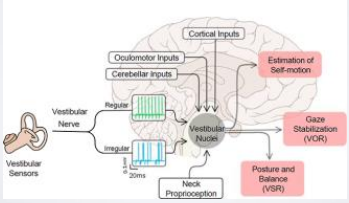
- Activation of the vestibular system causes eye movement
- Vestibular nuclei receive inputs from cortex, oculomotor pathways, cerebellum, neck proprioceptors
- For clear vision, head movement must be compensated almost immediately
- The three neuron arc acts in less than 10 ms, and thus the vestibulo-ocular reflex is one of the fastest reflexes



23

VESTIBULAR PATHWAY

- The eye movements stabilize images on the retinas during head movement by producing eye movements in the direction opposite to head movement to preserves the image on the center of the visual field
- Output regulates gaze stabilization via the vestibulo-ocular reflex (VOR), posture and balance via the vestibulo-spinal reflex (VSR), and contribute to an estimation of self motion



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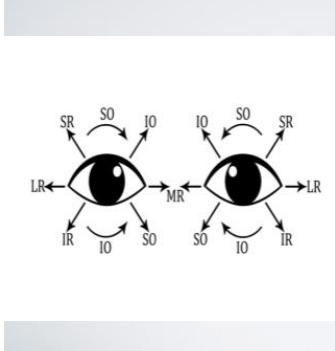
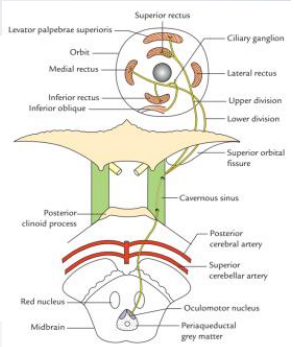
THE OCULOMOTOR PATHWAY

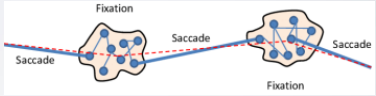




25

FUNCTIONAL VISUAL SKILLS

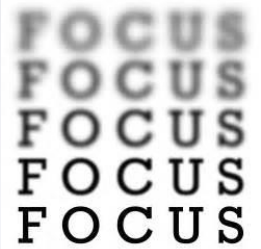
- Oculomotility
  - Fixations
  - Saccades
  - Pursuits



26

FUNCTIONAL VISUAL SKILLS

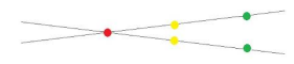
- Accommodation
  - Monocular
    - Sustained
    - Facility
  - Binocular
    - Facility



27

FUNCTIONAL VISUAL SKILLS

- Posture
  - Exophoria
  - Esophoria
  - Vertical Heterophoria



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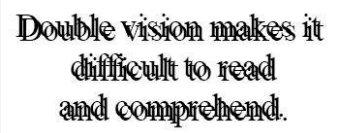
FUNCTIONAL VISUAL SKILLS

- Vergence
  - Convergence
  - Divergence
  - Smooth
  - Jump



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FUNCTIONAL VISUAL SKILLS

- Vergence vs Binocular Function
  - Near Point of Convergence
  - Red Lens Near Point of Convergence

30

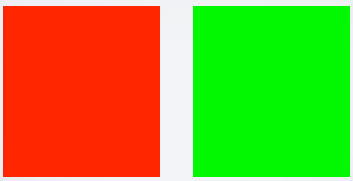
FUNCTIONAL VISUAL SKILLS

- Binocular Function
  - Luster
  - First Degree Fusion
  - Second Degree Fusion
  - Third Degree Fusion

31

FUNCTIONAL VISUAL SKILLS

- Binocular Function
  - Luster



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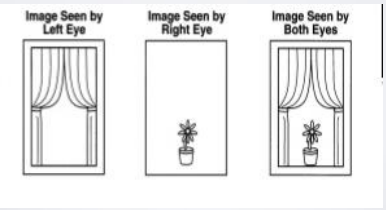
FUNCTIONAL VISUAL SKILLS

- Binocular Function
  - First Degree Fusion (Simultaneous Perception)



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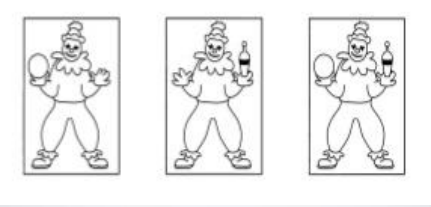
FUNCTIONAL VISUAL SKILLS

- Binocular Function
  - Second Degree Fusion (Flat Fusion)



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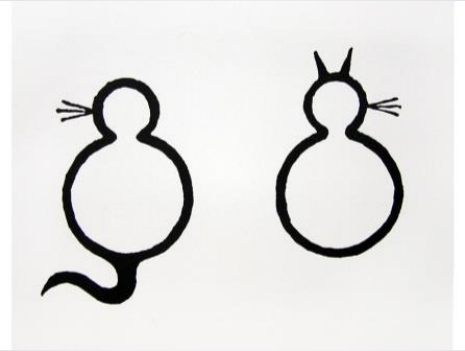
FUNCTIONAL VISUAL SKILLS



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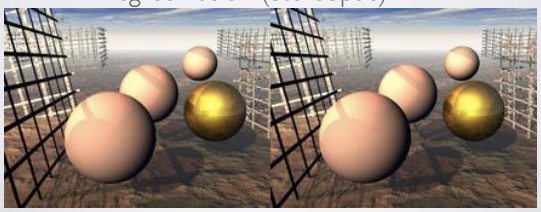
FUNCTIONAL VISUAL SKILLS

- Binocular Function
  - Second Degree Fusion (Flat Fusion)

36

FUNCTIONAL VISUAL SKILLS

- Binocular Function
  - Third Degree Fusion (Stereopsis)



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FUNCTIONAL VISUAL SKILLS

- Binocular Function
  - Third Degree Fusion (Stereopsis)

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FUNCTIONAL VISUAL SKILLS

- Binocular Function
  - Fixation Disparty
  - Accommodative-Convergence Relationships
  - Integration

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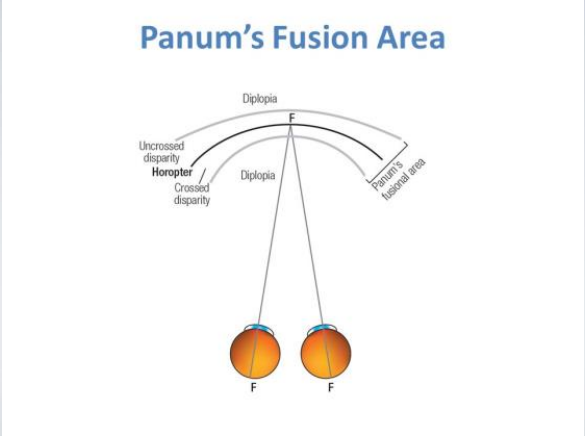

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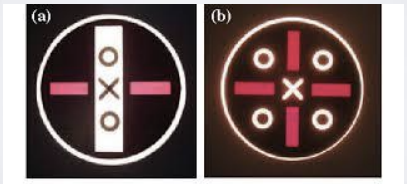
FUNCTIONAL VISUAL SKILLS

- Binocular Function
  - Fixation Disparty



ure 1. Mallett Distance Fixation Disparity Test. The left h

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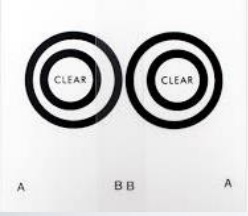
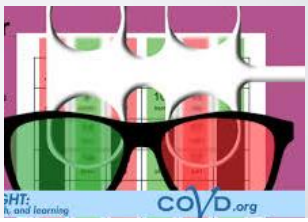
FUNCTIONAL VISUAL SKILLS

- Binocular Function
  - Accommodative-Convergence Relationships





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FUNCTIONAL VISUAL SKILLS

- Functional adaptations to problems with binocularity
  - Amblyopia
  - Strabismus

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FUNCTIONAL VISUAL SKILLS

- Functional adaptations to problems with binocularity
  - Strabismus
    - Magnitude
    - Depth/Frequency
    - Laterality
    - Viewing Distance
    - Comitancy

44

FUNCTIONAL VISUAL SKILLS

- Functional adaptations to problems with binocularity
  - Strabismus
    - Vestibular dysfunction?
    - Cross fixation?
    - Problems with motion processing?
    - Low tone?
    - Problems with bilateral integration?

45

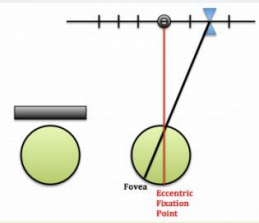
FUNCTIONAL VISUAL SKILLS

- Functional adaptations
  - Eccentric Fixation (Strabismus & Amblyopia)
  - Anomalous Correspondence (Strabismus)

46

FUNCTIONAL VISUAL SKILLS

- Functional adaptations
  - Eccentric Fixation



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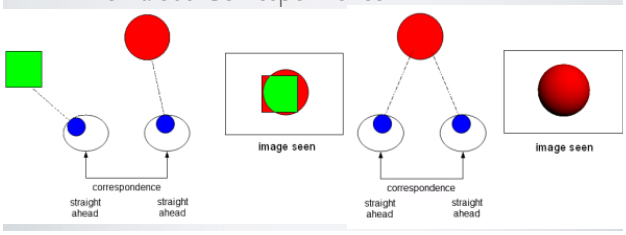
FUNCTIONAL VISUAL SKILLS

- Functional adaptations
  - Anomalous Correspondence



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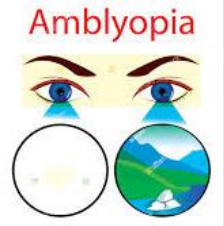
FUNCTIONAL VISUAL SKILLS

- A word on patching and eye muscle surgery
  - Amblyopia
  - Strabismus

49

FUNCTIONAL VISUAL SKILLS

- Amblyopia
  - The amblyopic individual has poor depth perception, dysfunction in micro-eye movements affecting reading fluency, visual perception and processing ability causing poor judgments, deficiencies in eye hand and general coordination leading to errors in visually directed motor behaviors.



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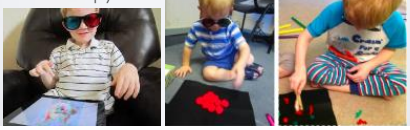
FUNCTIONAL VISUAL SKILLS

- Amblyopia
  - An outdated standard treatment approach called occlusion therapy (eye patching) or atropine penalization eye drops in which the treatment causes the patient to feel worse due to it's serious negative side effects, compliance is poor and the patient only gains partial improvements.

51

FUNCTIONAL VISUAL SKILLS

- Amblyopia
  - Research is clear: www.amblyopiaproject.com
  - Binocular treatment for amblyopia is more effective, has less side effects and results are maintained longer than occlusion therapy



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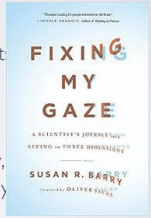
FUNCTIONAL VISUAL SKILLS

- Strabismus
  - Journal of Pediatric Ophthalmology and Strabismus. 2018;55(1):14-22https://doi.org/10.3928/01913913-20170703-16
  - March 05, 2018 - Long-Term Surgical Outcomes for Large-Angle, Infantile Esotropia; American Journal of Ophthalmology
  - "After a mean follow-up of 40 months, 20 (23%) patients had a successful outcome compared to 68 (77%) treatment failures. Of the 68 treatment failures, 59 had residual or recurrent esotropia compared to 9 with sequential exotropia." With 2 surgeries plus botulism toxin use: still 73% failures.

53

FUNCTIONAL VISUAL SKILLS

- Strabismus
  - "We think of standard medical care as constantly moving forward, providing more effective treatment from year to year. Yet, standard ophthalmological treatment for crossed eyes (strabismus) or lazy eye (amblyopia) has hardly changed in the last century even though these treatments, patching and surgery, do not address the fundamental problems and rarely lead to stereovision. — Neurobiologist, Dr. Sue Barry



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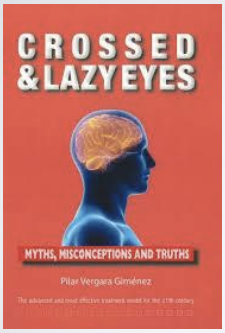
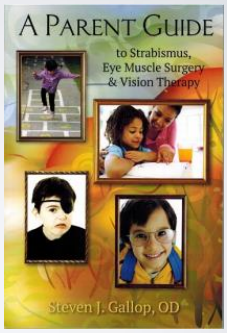
FUNCTIONAL VISUAL SKILLS





55

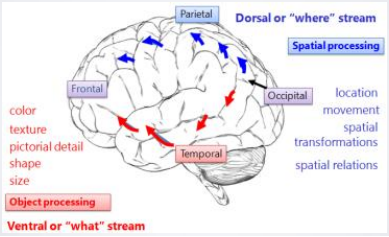
FUNCTIONAL VISUAL SKILLS

WHERE TO LOOK?

56

DORSAL AND VENTRAL SYSTEMS: *HIGHER LEVEL VISUAL PROCESSING*

- Vision for **perception** is subserved by processing in the **ventral** stream
- Vision for **action** thought to be subserved by the **dorsal** stream



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DORSAL AND VENTRAL SYSTEMS: *HIGHER LEVEL VISUAL PROCESSING*

DORSAL/M Pathway	**VENTRAL**/P Pathway
AMBIENT	FOCAL
Proactive	Reactive
Lightning fast	Slower
Subconscious	Conscious
Movement	Detailed
Spatial Localization	Object identification
Figure ground segregation	Related to figure in the ground
Larger impact on balance, posture & function	Secondary to dorsal processing

58

DORSAL STREAM

- Considered our ambient system
- More primitive visual system is present at birth
- An unconscious function that links vision and motor
- Composed of magnocells that respond to large and fast moving stimuli

59

DORSAL STREAM

- Processed first and then must match with kinesthetic, proprioceptive, vestibular, and even tactile systems
- Responsible for spatial orientation, general awareness, balance, posture, movement detection, localization
- Allows for the development of concepts of midline, position, and orientation

60

DORSAL STREAM

- **Feed-forward phenomenon**
  - 20% of the nerve fibers from the eye do not go to the occipital cortex—goes to midbrain
  - Visual information relayed from the midbrain to the occipital cortex to pre-program the higher cortical areas to ***first evaluate visual information spatially before focalizing on detail***

61

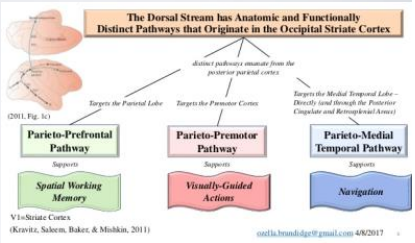
DORSAL STREAM

- Release from focalization for movement- frees up higher level process from postural organization and control
- Suppresses background info to allow for attention
- *Major contributions to the overall cognitive function*

62

DORSAL STREAM

- Dorsal Stream splits into 3 pathways at Posterior Parietal Cortex
  - Parieto-Prefrontal Pathway
  - Parieto-Premotor Pathway
  - Parieto-Medial Temporal Pathway



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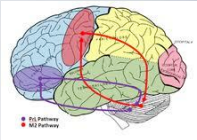
DORSAL STREAM



- Dorsal Stream splits into 3 pathways at Posterior Parietal Cortex
  - Parieto-Prefrontal Pathway
    - Initiation and control of eye movements important for reading
    - ***Spatial working memory,*** which is important in determining where to look next
    - Important for navigating through new environment
    - This pathway provides input to the prefrontal cortex necessary for top down control of visuospatial processing

64

DORSAL STREAM

- Dorsal Stream splits into 3 pathways at Posterior Parietal Cortex
  - Parieto-Premotor Pathway
    - Has projections to both dorsal and ventral premotor cortex, receiving vestibular input from the cerebellum
    - Visually guided action for integration of body movement and vision, visually guided reaching and grasping
    - Provides ***coordinated maps of body position***
    - Integration of body movements with ***vision for navigation***

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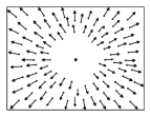
DORSAL STREAM

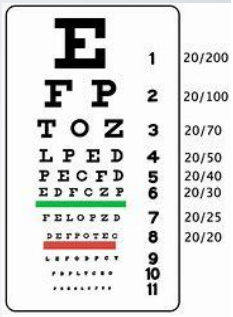


- Dorsal Stream splits into 3 pathways at Posterior Parietal Cortex
  - Parieto-Medial Temporal Pathway
    - Connections to limbic areas (learning from past visual experiences)
    - Specialized for processing distant space
    - Sensitive to speed of optic flow that is used in updating one's position during navigation
    - Appropriate coordinated head and body postural reflexes are generated as information flows through the vestibulocerebellar and vestibulospinal tracts

66

VENTRAL STREAM

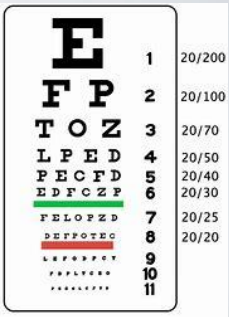
- The ventral system is associated with the primary visual pathway
- Develops after birth
- Much slower than the dorsal system



67

VENTRAL STREAM

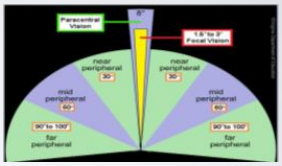
- Mediated by the parvocellular cells
- Cells that react to stationary small targets, detail and color



68

VENTRAL STREAM

- 80% of visual fibers from the optic nerve
- Responsible for detail, identification, texture, color, attention



69

VENTRAL STREAM

- It is part of our conscious perceptions
- Traditional ophthalmic and optometric exam

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DORSAL AND VENTRAL SYSTEMS — SENSORY COHERENCE

- There is no such thing as a pure visuomtor task nor a pure perceptual task
- Under most normal circumstances our actions are visually co-determined by complementary processing in both dorsal and ventral streams

71

DORSAL AND VENTRAL SYSTEMS — SENSORY COHERENCE

- Information must be processed and combined efficiently, and rise to consciousness simultaneously
- An imbalance between the two processes results in information being received by the occipital cortex without spatial pre-programming

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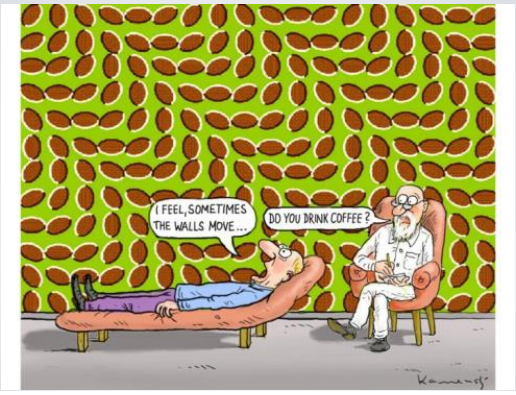
DORSAL & VENTRAL



73

DORSAL PROCESSING

- *"Why does my child insist on getting so close to the television?"*
- "Seeing objects in the distance is difficult, as the further away things are, the more visual information there is in the scene. For this reason, children with dorsal stream dysfunction like to get very close to the television, presumably so that they can give visual and auditory attention to the individual elements of a moving scene." Dutton et al

74

DORSAL PROCESSING

- Dorsal stream dysfunction
  - Being unable to find a friend or relative in a group
  - Having difficulty finding a toy on a patterned background

75

DORSAL PROCESSING

- Dorsal stream dysfunction
  - Being unable to find an item of clothing in a pile of clothes - and having to spread out clothes to find the chosen item
  - Being unable to find a toy among a pile of toys and finding it easier to find a toy against a plain background

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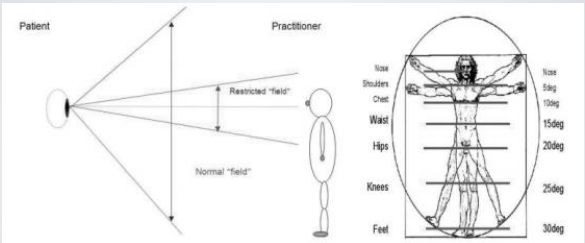
DORSAL PROCESSING



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VISION, AS A PROCESS, EMERGES

- Input from the eye via the dorsal system leads to unconscious interaction with vestibular/auditory/ tactile and proprioception allowing for bottom up visual processing (anti-gravity and localization— where am I? where is it?)
- Input from the eye via the ventral system interacts with attention mechanisms to derive conscious meaning from the external world by interaction and identification, or top down visual processing— what is it?

78

VISION, AS A PROCESS, EMERGES

- Sensory coherence between dorsal and ventral processing allows for figure-ground relationships (etc) to ensure localization and identification can occur
- This emergent process allows visualization (visual planning) and communication— what do I have to do to get it?

79

VISION, AS A PROCESS, EMERGES

- *Vision is motor… not in the sense that vision is fully equated with motor action, but that it is infused with motor knowledge that helps us predict the consequences of our actions.*

80

VISION, AS A PROCESS, EMERGES

- Sight is merely what a person sees in a moment
- Vision enables the person to use eye sight intelligently to comprehend or solve problems
- Vision guides purposeful movement and success in reaching goals
- Vision depends on the interconnections between all dimensions of development: auditory-language, sensory, motor and emotional

81

MOVEMENT RELIES ON VISUAL SPATIAL KNOWLEDGE

- Vision embraces space and guides movement through space— sense of direction
- Visual information tells the mind how to think and relate, and the body how to move
- If poor, interferes with movement, sequencing, language because visual experiences are distorted or inconsistent

82

MOVEMENT RELIES ON VISUAL SPATIAL KNOWLEDGE

- Daily adaptation, executive function, interactions with family peers, and reading/math become derailed
- Interferes with symbolic development and abstract thinking

83

USEFUL THEORIES FOR THERAPEUTIC PLANNING

- **Development via Piaget**
- Top down Visual Processing (Richard Gregory - 1970)
- Bottom up Visual Processing (James Gibson -1966)
  - Action based theories of perception
  - Embodied Cognition

84

PIAGET

- Intellectual development is based on two components
  - Sensory Motor- involves action
  - Operational- involves objects
- A child understands his physical world by creating logical, mental representations
- Assimilation and accommodation based on these constructs lead to cognitive development and therefore physiological growth

85

PIAGET

- Improvement in the perceptual sensory system occurs through environmental stimulation
- Not all activities are perceptual activities – Only activities involving children in sensory integration
  - Improve Balance- Vestibular
  - Spatial Awareness- Understanding external spaces around the child (Audition & Vision)

86

PIAGET

- Not all activities are perceptual activities – Only activities involving children in sensory integration
  - Temporal Awareness- Ability to predict when stimuli arrives (all senses)
  - Body & Directional Awareness- Ability to know (proproception)

87

USEFUL THEORIES FOR THERAPEUTIC PLANNING

- Development via Piaget
- **Top down Visual Processing** (Richard Gregory - 1970)
- Bottom up Visual Processing (James Gibson -1966)
  - Action based theories of perception
  - Embodied Cognition

88

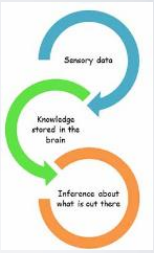
USEFUL THEORIES FOR THERAPEUTIC PLANNING

- Top down Visual Processing
  - Refers to the use of contextual information in pattern recognition.
  - For example, understanding difficult handwriting is easier when reading complete sentences than when reading single and isolated words.
  - This is because the meaning of the surrounding words provide a context to aid understanding.

89

USEFUL THEORIES FOR THERAPEUTIC PLANNING

- Top down Visual Processing
  - Stimulus information from our environment is frequently ambiguous so to interpret it, we require higher cognitive information either from past experiences or stored knowledge in order to makes inferences about what we perceive.
  - Helmholtz called it the 'likelihood principle'.



90

USEFUL THEORIES FOR THERAPEUTIC PLANNING

- Top down Visual Processing- Charlie Chaplin Optical Illusion
- ***Our perceptions of the world are hypotheses based on past experiences and stored information.***
  - Sensory receptors receive information from the environment, which is then combined with previously stored information about the world which we have built up as a result of experience.
  - The formation of incorrect hypotheses will lead to errors of perception

91

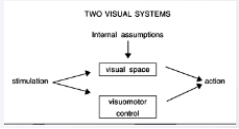
USEFUL THEORIES FOR THERAPEUTIC PLANNING

- Development via Piaget
- Top down Visual Processing (Richard Gregory - 1970)
- **Bottom up Visual Processing** (James Gibson -1966)
  - Action based theories of perception
  - Embodied Cognition

92

ACTION-BASED THEORIES OF PERCEPTION

- Action is a means of acquiring perceptual information about the environment (Gibson 1966, 1979)
- Examples:
  - Turning around alters your spatial relations to surrounding objects and which of their properties you visually perceive
  - Moving your hand over an object's surface enables you to feel its shape, temperature, and texture



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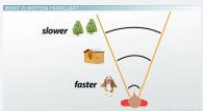
ACTION-BASED THEORIES OF PERCEPTION

- Action is a means of acquiring perceptual information about the environment (Gibson 1966, 1979)
- Visual examples:
  - .The pattern of optic flow in the retinal image produced by forward locomotion contains information about the direction in which you are heading
  - Motion parallax is a "cue" used by the visual system to estimate the relative distances of objects in your field of view



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ACTION-BASED THEORIES OF PERCEPTION

- Visual information is processed to extract identity, location, and affordances (ways that we might interact with objects)
- People can perceive their ability to interact with the world based on affordances and effectivities.
  - For example; I can open a door using the handle (an affordance) because of my hands (effectivities).

95

ACTION-BASED THEORIES OF PERCEPTION

- People can perceive their ability to interact with the world based on affordances and effectivities.
  - We may find that different effectivities affect the way that we perceive an affordance.
  - For example; a cat may mimic my ability to open a door by using its paws (feet) as effectivities but it is somewhat unlikely that a mouse would be able to do the same and thus the mouse would not see the door handle as an affordance at all.

96

ACTION-BASED THEORIES OF PERCEPTION

- Vision is something we do, rather than something that happens in us
- Vision does not produce a faithful metric-preserving replica of the outside world inside the head
- Vision is an **exploratory** activity, attuned to ways in which sensory stimulation changes with movement
  - Such as when a retinal image changes when one walks around an object.

97

EMBODIED COGNITION

"Many features of cognition are embodied in that they are deeply dependent upon characteristics of the physical body of an agent, such that the agent's beyond-the-brain body plays a significant causal role, or a physically constitutive role, in that agent's cognitive processing."

—RA Wilson and L Foglia, Embodied Cognition in the Stanford Encyclopedia of Philosophy

98

EMBODIED COGNITION

- A person's cognition is strongly influenced by aspects of an agent's body beyond the brain itself
- Expands cognitive processing beyond the brain and the body, extending it outward into the person's world
- The most common definitions involve the straight-forward claim that "states of the body modify states of the mind."

99

EMBODIED COGNITION

- Theories of embodied cognition have suggested, following Piaget, that cognitive abilities may have evolved within the context of ancestral abilities for interacting with the world.
- Our ability to think about the world results from the internalization of the processes of predicting the consequences of actions.

100

EMBODIED COGNITION

- As the sensorimotor control system gradually evolved, it began to predict increasingly abstract consequences of behavior.
- This eventually allowed the ***mental rehearsal*** of entire sequences of acts and ***evaluation of their potential outcomes***, without overt motor activity.

101

EMBODIED COGNITION

- This hypothesis is consistent with the close relationship between mental imagery and the systems for motor preparation.
- Potentially explains how an organism may go beyond merely reacting to properties of the immediate environment and act in a goal-directed manner.

102

EMBODIED COGNITION

- Research shows
  - (1) how cognition can be influenced and biased by states of the body (e.g., Eerland et al., 2011)
  - or the environment (Adam and Galinsky, 2012)
  - or (2) that abstract cognitive states are grounded in states of the body and using the former affects the latter (e.g., Lakoff and Johnson, 1980, 1999; Miles et al., 2010).

103

EMBODIED COGNITION

- Visual Search
  - Action intention can affect processing in visual search, with more orientation errors for pointing than for grasping
  - Participants either pointed to or grasped target objects of 2 colors and 2 orientations (45° and 135°).
  - There were randomized numbers of distractors as well (0, 3, 6, or 9), which differed from the target in color, orientation, or both.

104

EMBODIED COGNITION

- Visual Search
  - A tone sounded to inform participants which target orientation to find.
  - Participants kept their eyes on a fixation point until it turned from red to the target color.
  - The screen then lit up and the participants searched for the target, either pointing to it or grasping it (depending on the block).

105

EMBODIED COGNITION

- Visual Search
  - Results from the experiment show that accuracy decreases with an increase in the number of distractors.
  - Overall, participants made more orientation errors than color errors.
  - There was no main effect of accuracy between the pointing and grasping conditions, but participants made significantly fewer orientation errors in the grasping condition than in the pointing condition.

106

EMBODIED COGNITION

- Visual Search
  - Color errors were the same in both conditions.
  - Because orientation is important in grasping an object, these results fit with the researchers' hypothesis that the plan to grasp an object will aid in orientation accuracy.
  - This supports embodied cognition because action intention (planning to grasp an object) can affect visual processing of task-relevant information (orientation).

107

EMBODIED COGNITION

- Posture-Modulated Estimation
  - Experiments investigated whether body posture influenced people's estimation of quantities.
  - According to the mental-number-line theory, people mentally represent numbers along a line with smaller numbers on the left and larger numbers on the right.

108

EMBODIED COGNITION

- Posture-Modulated Estimation
  - The hypothesis was that surreptitiously making people lean to the right or to the left would affect their quantitative estimates.
  - Participants answered estimation questions while standing on a Wii Balance Board.

109

EMBODIED COGNITION

- Posture-Modulated Estimation
  - Posture was manipulated within subjects so that participants answered some questions while they leaned slightly to the left, some questions while they leaned slightly to the right, and some questions while they stood upright.
  - Crucially, participants were not aware of this manipulation.
  - **Estimates were significantly smaller when participants leaned to the left than when they leaned to the right.**

110

VISION IS LEARNED

- Vision is what people depend on to create internal, mental representations of the outer world.
- Vision reflects the emotional experience of oneself and others, acquired through gaze and tone during interactions.
- Vision provides comprehension of what one sees, of the sequential order in which it is seen, and of the space in which it takes place.
  - Vision underlies movement and the sequencing of intentional actions and thought in motor planning.

111

VISION IS LEARNED

- We can gain a clue about the failure of binocular vision development by differentiating the sensory vs. motor processes in auditory development vs. visual development.
- Example: the child with cerebral palsy (CP).

112

VISION IS LEARNED

- The prevalence of hearing deficits in this population is only 12% but the prevalence of strabismus is much higher.
- Moreover, the prevalence of strabismus is directly related to the degree of motor impairment.
- Hermann von Helmholtz was brilliant scientist in the 1800s in Germany who understood that the development of binocular vision was a **learned** rather than innate process.

113

VISION IS LEARNED

- Helmholtz's argued that motor learning is rooted in head-to-toe early experiences.
- That is why auditory development is comparatively normal in CP, as cortical localization and tonotopic maps of sound localization can develop largely unimpaired.

114

VISION IS LEARNED

- A primary difference in humans between audition and vision is motor *exploration*.
- The sophistication in binocular visual development is reflected in how well *the eyes can move independent of head movement*.

115

VISION IS LEARNED

- In the human auditory system the ears are never called upon to move independent of the head.
- The gross and fine motor restrictions in CP directly limit the ability of the infant to learn binocular integration.
- The infant is restrained in her ability to develop **cross-patterning, reciprocal interweaving, crossing the midline, hand and body feedback to localize space, and body balance** to establish that oculocentric localization on the midline remains linked with egocentric localization on the midline – all factors in the learned development of normal binocular vision.

116

VISION IS LEARNED

- In this sense, a child with amblyopia has a form of monocular learning disability and child with strabismus has a form of binocular learning disability.
- While the significance of perceptual learning to counteract amblyopia is now widely recognized, its significance in binocular vision development is only now re-emerging in strabismus.

117

VISION IS LEARNED

- "Other types of movement – of the body or the hand – collaborated in the exploratory function of the eyes, and this enabled the subject to have a representation of objects in space and record within his inner concept of time his memory of the progress of external events."

118

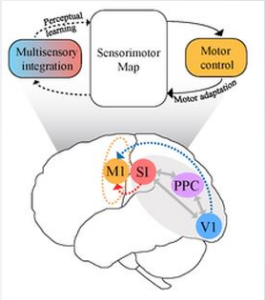
VISION IS LEARNED

- "So the eye was able to continuously 'calibrate' its relations with visual space by taking into account, at the level of perceptual processes, information about the spatial environment derived from other sense organs."

119

VISION IS MOTOR

- Human perception of hand position is multisensory.
- The brain can estimate it visually, from an image on the retina, and proprioceptively, from receptors in the joints and muscles.
- The sensory inputs determining these percepts are subject to changes in environmental factors (e.g., lighting) and internal factors (e.g., movement history).



120

VISION IS MOTOR

- Multisensory integration of visual and proprioceptive estimates gives us flexibility to cope with such changes.
- For example, washing dishes with the hands immersed in water creates a spatial misalignment between vision and proprioception, as water refracts light.

121

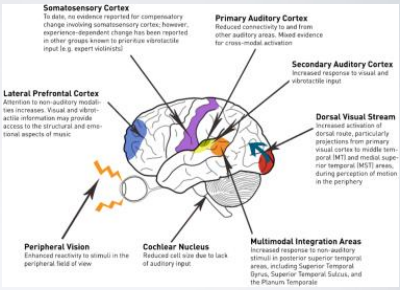
VISION IS MOTOR

- The brain resolves this conflict by realigning visual and/or proprioceptive estimates of hand position.
- Such perceptual learning can alter perceived hand position, but it is unclear how movements planned with that hand are affected.

122

BUILDING MIND MAPS

- The integration of the senses is totally interactive: when an event occurs in one sensory system, the other senses become attuned to the spatial coordinates of that event automatically, covertly.



123

BUILDING MIND MAPS

- The very expectation of an event in a certain location has now been demonstrated to actually improve the judgments of the other sense modalities to that location.
- A multimodal, internal spatial map is being actively constructed and consulted— It is subconscious and contains data from visual, somatosensory, auditory, and vestibular inputs.
- This develops the spatial reality with which the person operates and each person's mind map accuracy is dependent on the **quality of the input.**

124

BUILDING MIND MAPS

- Feedback and feedforward then enable the individual to operate as adequately as he can, and sometimes when in the data is in error the result is the beginning of a visual problem.
- This is especially possible when either the stress of the environment, emotional stress, nutritional depletion or faulty learning of the neural systems, force structural adaptations upon the end organs: in our area of concern, the eye and its motor systems.

125

MULTIDIMENSIONALITY OF SPACE— FRAMES OF REFERENCE

- The **egocentric** frame of reference for movement is determined by the direction of intended movement linked to corresponding body parts involved
- **Allocentric** is a frame of reference centered on points in space distinct from the one that the perceiver is occupying

126

MULTIDIMENSIONALITY OF SPACE— FRAMES OF REFERENCE

- "This might lead one to believe that the frame of reference of visual perception is centered on the eyes, but this cannot be right. The position of one's body in relation to the perceived object is at least as important as the position of one's eyes. When we turn our head to the left we do not perceive the objects to the left of our body as in front of ourselves." — Susanna Schellenberg

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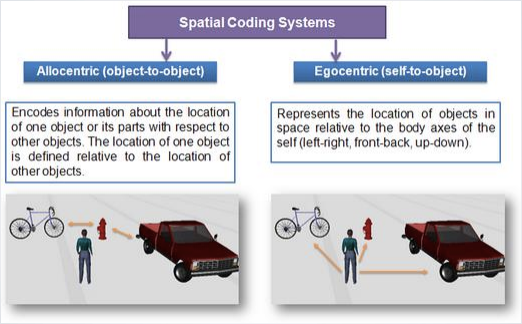
MULTIDIMENSIONALITY OF SPACE— FRAMES OF REFERENCE



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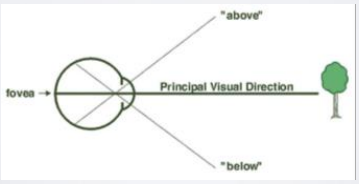
MULTIDIMENSIONALITY OF SPACE— FRAMES OF REFERENCE

- Oculocentric Visual Direction is the visual direction of an object that can be represented by a line that joins the object and the fovea called the visual axis



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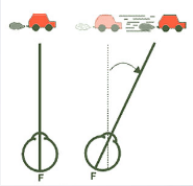
MULTIDIMENSIONALITY OF SPACE— FRAMES OF REFERENCE

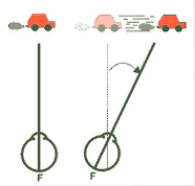
- Egocentric visual direction refers to the direction of an object in space relative to one self, rather than the eyes.
- Egocentric direction is determined by retinal position, proprioceptive information about the eye, head and body position and the vestibular system



130

MULTIDIMENSIONALITY OF SPACE— FRAMES OF REFERENCE

- All this information allows us to determine if a change in retinal position is due to object movement or due to eye or head movement.



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MULTIDIMENSIONALITY OF SPACE— FRAMES OF REFERENCE

- **Clinical Relevance**
- Strabismus- oculocentric localization often results in a shift of the egocenter away from the midline and referenced more toward one eye
- Acquired brain injury- the opposite often occurs, where oculocentric localization remains on the midline as long as the eyes are aligned, but egocentric localization undergoes a midline shift.

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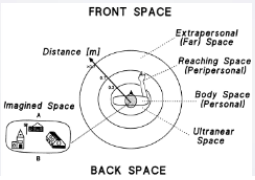
VISUAL FRAMES OF REFERENCE

- Personal space is the space within one's body schema
- Peripersonal space is outside one's immediate body schema or egocenter, but within the range of touch
- Extrapersonal space is beyond the range of interaction with one's body, but within the distance of visual capture.



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WHAT IS SPATIAL THINKING?

- Spatial thinking, or spatial reasoning, concerns the positions of objects, their shapes, their spatial relations to one another and the movement they make.
- It involves understanding and remembering the relative locations of objects in the mind

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WHAT IS SPATIAL THINKING?

- Then through imagining or visualizing, objects are manipulated through mental movement or transformation to form new spatial relations in different frames of reference.
- Spatial thinking is motor visualization, it is building a mind map. Remember, visual information is relayed to ***first evaluate visual information spatially before focalizing on detail***.

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WHAT IS SPATIAL THINKING?

- Neuroscientists find that specific regions in the brain responsible for thinking about location and spatial relationships develop in very early childhood.
- Infants as young as 4 months have been found to demonstrate abilities related to mental rotation.
- https://www.tandfonline.com/doi/full/10.1080/00221340701809108?scroll=top&needAccess=true3

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WHAT IS SPATIAL THINKING?

- Spatial reasoning skills are cumulative and durable.
- Those who master the skills in early childhood will have more opportunities to use it to acquire and organize additional information throughout their lives.
- https://www.tandfonline.com/doi/full/10.1080/00221340701809108?scroll=top&needAccess=true3

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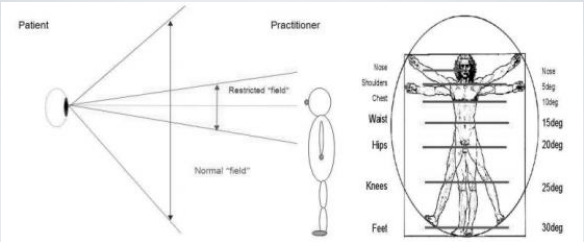
SPATIAL FIELD



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DORSAL AND VENTRAL SYSTEMS— SPATIAL PROCESSING

- The dorsal stream encodes spatial properties in ***egocentric*** coordinates, where things are located from the position of perceiver
- The ventral stream encodes spatial properties in ***allocentric*** coordinates, where things are located relative to other things in the visual field

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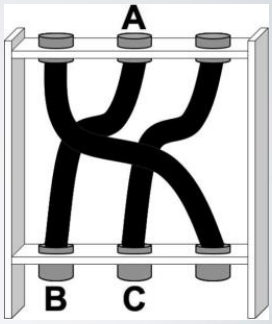
VISUALIZATION

- Visualization is using visual imagery to mentally represent an object or movement pattern.
- It is a powerful skill in spatial reasoning and problem solving.
- Young children can be taught to use visualization to enhance their spatial thinking.



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VISUALIZATION

- For example, young children often have "gravity bias".
- In an experiment, when a ball drops, preschoolers tend to think that it will appear directly below, even if the ball drops down a twisted tube.
- But when they are instructed to **visualize the path of the ball before answering**, more kids got the right answer.

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VISUALIZATION

- Research has demonstrated that simply inviting 3-year-olds to use visual imagery can have a remarkable influence on their ability to solve an otherwise difficult spatial problem.
- It appears that very young children do not spontaneously visualize spatial events when problem-solving; they require an invitation to do so.
- For young children, then, the first step toward using visual imagery may be an explicit cue to use it.

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VISUALIZATION

- Motor imagery can alter the neuronal action in the primary sensorimotor areas similar to what would be observed with an actual performed movement.
- For example, tetraplegic patients are able to operate an EEG-based control of a hand orthotic with nearly 100% classification accuracy by mental imagination of specific motor commands.

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VISUALIZATION

- The general idea is that motor imagery is part of a wider notion of the "motor representation" linked to the intention and preparation for movement.
- The normally unconscious process of motor representation can be conscious under some circumstances.
- A motor image is a conscious motor representation… therefore in all of the following techniques, the patient should be asked to visualize the movement before it is executed.

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VISUALIZATION

- Awareness of movement is the key to improving movement
- Our sensory systems are intimately related to the motor systems, not separate from it.
- Sensations purpose to orient, guide, help control, coordinate and assess the success of a movement…vision for action!
- Research shows that long term change occurs most in reading when a person pays close attention while learning

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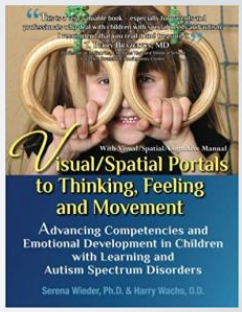
VISUAL SPATIAL COGNITIVE PROFILE

- A systemic approach to observation
- A Visual-Spatial Perspective for perceptual-Motor Learning
- Outlines a hierarchy of visual spatial developmental capabilities, the functions served by each, and suggested interventions



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VISUAL SPATIAL COGNITIVE PROFILE: GENERAL MOVEMENTS

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Reflexes: Are the primitive and postural reflexes fully integrated?	Activities selected to help integrate reflexes and give the child greater control over their movement, i.e. In-utero movements, animal walks, soccer, spinal massage, spinning, etc.	Presence of these reflexes inhibits smooth and efficient body movements needed in everyday life. Reflex links between sensory stimulus and motor response are present in early infancy and usually disappear as cortical development takes over sensory procesing

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VISUAL SPATIAL COGNITIVE PROFILE: GENERAL MOVEMENTS

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Mental Map: Do they have an understanding of how to use their own body and/or where they are in space?	Activities selected to increase awareness, i.e. body lifts, silhouette, dimensions, body measure, body questions, joints, ladder work, bean bag dodge, static imitative movements.	Reduces bumping into objects and enhances understanding of personal space.

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VISUAL SPATIAL COGNITIVE PROFILE: GENERAL MOVEMENTS

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Integration: Can they perform coordinated movements across all axes of the body?	Examples: Creeping bimanual circles, swimming, angels in the snow, mountain climb, trampoline.	Assists with motor planning and organization.

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VISUAL SPATIAL COGNITIVE PROFILE: GENERAL MOVEMENTS

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Balance: Can they intelligently make use of gravity to stabilize body movement?	Examples: Walk rail, kick over, balance board wrestle, prism activities	Needed for sports, reading, writing, reducing clumsiness.

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VISUAL SPATIAL COGNITIVE PROFILE: GENERAL MOVEMENTS

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Rhythm: Can the person represent time through intrinsic and extrinsic movement presented visually, auditorily, and sonmato-sensoriliy (varied durations, pause and sequence)?	Examples: Rhythm is presented through lights, signs, sounds, using tapping, hidden tapping, recall tapping of varied duration, pause, and sequence of different body actions in varied patterns. Metronome to pace, Interactive Metronome.	It is the knowledge of pacing one's own and others actions and responding accordingly. Includes any timed actions.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: GENERAL MOVEMENTS

- Rebounder can be used to help assimilate primitive and postural reflexes, progressing through the levels of Mental Maps, Coordination of Body Axes, and Integration of Body C

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: GENERAL MOVEMENTS

- Jump/Stop: Count a certain # of jumps and then stop.
- Clap in and out of phase:
  - Ask the child to jump up and down and clap every time his feet land (in phase).
  - Clapping out of phase requires clapping in the air when the feet are not touching
  - Once the child can successfully clap both in phase and out phase, ask him to switch in and out phase on demand without stopping movement.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: GENERAL MOVEMENTS

- Jumping Jacks – arms and legs out together, with arms over head, arms returning to side as legs touch down.
- Jumping Jills – the opposite of Jacks: arms at side while legs separated, then arms in the air as legs touch down.
- Switch between the two without stopping the rhythm

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: GENERAL MOVEMENTS

- Strides – stand with R leg forward and L leg behind, extending R arm in front (same side as leg).
  - Say "switch" and child makes the switch to L arm and L leg extended while jumping in the air.
  - Once the switch is smooth, do "not same" – i.e. L leg forward and R arm extended.
  - Say "switch" and child makes switch to R leg forward and L arm extended.
  - Once smooth, have child switch between same and not same.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: GENERAL MOVEMENTS

- Stroop Chart/Hart Charts
  - While the child is jumping on the trampoline you call out either "word" or "color" as you point to a word, and the child identifies what you're pointing to accordingly

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: GENERAL MOVEMENTS

- Infinity Walk
  - Walk at a comfortable but continuous pace. Look at visual target on the wall. Walk in a sideways figure of 8 or infinity symbol while maintaining visual target. When you are turning around bring head and eyes back to the target as quickly as possible.

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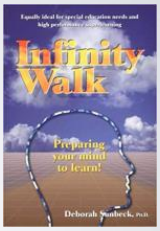
ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: GENERAL MOVEMENTS

- Infinity Walk
  - Add tapping opposite hand and knee as the patient fixates on the chart. Add reading letters on a chart. Use the stroop chart.



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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- An improved mental map allows the patient to move one part of the body in isolation without motor overflow, then to move multiple parts in unison, and then in a specific sequence.
- Body Lifts
  - The patient lies prone on the floor, arms at his side, and the therapist touches the part or parts to be moved.
  - The following body lifts are listed in hierarchical order, meaning that one should be accomplished successfully before the next is attempted.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- ***One Body Part*** – major, such as head or arm
- ***Two Body Parts*** – homolateral
- ***Two Body Parts*** – contralateral
- ***One Body Part*** – specific, such as shoulder or elbow
- ***Three Body Parts*** – simultaneously

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- ***Sequence*** – touch two and then three body parts, asking the patient to lift and lower them in the sequence touched.
  - There is sequential motor memory involved here, as well as motor planning in programming and executing the movements.
  - ***Once accomplished, ask him to lift the parts in the reverse order in which they were touched.***

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- If these activities are too difficult to perform when the patient is lying prone, then try it with the patient supine or on his back. In all of the phases above, watch lack of fluidity.
- **Silhouette** – ask the child to stand facing a board, and trace the outline of his body on the board.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- Tell the child that the drawing represents the back of his body.
- Stand behind him and touch his back with your index finger.
- Ask him to draw an X on the silhouette where he thinks you touched him.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- If this is too difficult, tap the child on the head or shoulder rather than the back.
- After he's able to localize correctly, do a sequence and ask him to reproduce the sequence on the chalkboard.
- As with the body lifts, once he's able to reproduce the sequence correctly, have him do the sequence in reverse order.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- When this is done, instead of individual taps, trace a figure on the child's back, such as a triangle, and he should be able to reproduce that.
- As a variation, if one works with more than one child at a time, after you tap the child on the back, he has to reproduce the tap on the back of another child, who then has to map it onto the chalkboard.

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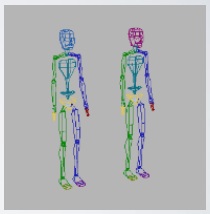
ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- **Joints** – this procedure helps a child get in touch with the hinges and pivot points of his body that allow him to twist, turn, and bend.
- He stands in an upright position imagining that his feet are glued to the floor.
- He can move any part of his body except his feet.
- Hold a two foot dowel or yardstick about two feet in front of the child and move it toward him.



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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- He has to decide how to move his body in order to avoid being touched by the stick without moving his feet.
- Have him explore different possibilities.
- Bring the dowel in from different angles and sides.
- The goal is flexibility in problem solving, rather than speed.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- **Dimensions** – our goal now is for the child to develop internal knowledge of his own dimensions, and how to project that into space.
- First, stand across the room and hold a dowel parallel to the child, and ask him to tell you to raise or lower it until it is level with his waist; then repeat the space match for knees and shoulders.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- If he has trouble judging, move closer.
- As a variation, ask the child to judge at what level of his body a fixed object in a room would intersect.
- For example, if there is a round table in the center of the room, at would the edge of the table be at his waist, above it, or below it as he walked up to the table?

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- **Estimating Body Length** – with the child standing, ask him if he were lying down, how many of him would it take to get from his position to the wall.
- If the child is 5 ft. tall, and he is 15 ft. from the wall, it would take three of him to make cover the distance.
- You don't want him to "count tiles" on the ceiling or use known calculations.
- The idea is to visually inspect the space, get a sense of his body dimension, and estimate the relationship.

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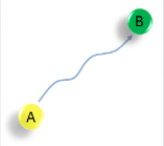
ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- **Estimating Distance** – same idea, but with asking the child how many steps it would take to get from Point A to Point B.
- Compare the estimation with "normal" vs. "small" vs. "large" steps.



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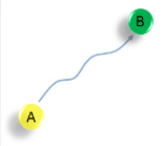
ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- Introduce a temporal component by asking the child to estimate how many of each type of step it would take to traverse the distance if he were walking slow vs. fast.
- Obviously a child has to have sufficient cognition to be able to conceptualize this, but it's a great visual thinking prelude, perhaps even a readiness skill to solving math word problems.



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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: MENTAL MAP OF BODY

- **Body Questions** – as another variant, how close would a child have to come to a wall before his outstretched arm would touch the wall?

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: INTEGRATION

- **Marsden Ball Walk Through**
  - Swing the suspended ball back and forth like a pendulum.
  - As the patient notices the ball with his side vision, he should walk through the path of the swinging ball, forward and backwards with the eyes open without letting the ball hit him.
  - Then close the eyes, visualize the balls trajectory, and begin to walk through with the eyes closed.
  - Can practice ambiently or focally viewing the ball.

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VISUAL SPATIAL COGNITIVE PROFILE: DISCRIMINATIVE MOVEMENTS - OCULAR MOVEMENT

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Fixation: Can they direct their eyes to a specific point in space?	Used in any activities with the eyes open.	Essential for visual attention.

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VISUAL SPATIAL COGNITIVE PROFILE: DISCRIMINATIVE MOVEMENTS - OCULAR MOVEMENT

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Tracking: Can they smoothly follow a moving target?	Washer stab, rotator and peg, suspended Marsden ball, flashlight tag.	A principle factor in eye-hand coordination, an intrinsic part in all daily activities including reading

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VISUAL SPATIAL COGNITIVE PROFILE: DISCRIMINATIVE MOVEMENTS - OCULAR MOVEMENT

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Focus: Can they see clearly at both near and far points? Can they quickly and efficiently change their point of focus?	Rock stick, near far Hart chart, far to near saccades.	Ability to see clearly when changing fixation from distance to near and vice versa.

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VISUAL SPATIAL COGNITIVE PROFILE: DISCRIMINATIVE MOVEMENTS - OCULAR MOVEMENT

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Convergence: Can they use both eyes to view an object at near point?	Pen top convergence, pegboard convergence, Straw and pointer	Inability to convergence will hinder spatial accuracy and academic development.

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VISUAL SPATIAL COGNITIVE PROFILE: DISCRIMINATIVE MOVEMENTS - OCULAR MOVEMENT

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Binocular Function: Do they have the knowledge of how to integrate their monocular systems to perform a binocular task?	Fusion work in Optometric Vision Therapy	Important in understanding and using three dimensional space.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Contraindications: Strabismus and Amblyopia
  - Anomalous Correspondence?
  - Eccentric Fixation?
  - Intractable Diplopia/Suppression

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Mental map of the eyes
  - Needed to develop knowledge of "Where are my eyes?" and "Can I make them move where I want them to move?"
  - The patient directs her eyes to move toward each of nine spatial areas
  - Without movements of head or body
    - Up and left —>Left —>Down and left —> Up —> Straight —> Down
    - Up and right —> Right —> Down and right

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Mental map of the eyes
  - Observe
    - Does the child move her eyes straight from point to point?
    - Do the eyes "stutter" mid swing or at the end of a swing?
    - Does the head move? chin?
    - Can the eyes push to the maximum movement in all meridians?
  - If difficult, place objects at fixations points and ask her to touch them to bring her eyes to the correct place in space

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Mental map of the eyes — **closed** eyes
  - The child sits or stands facing straight aged and both eyes are slightly closed.
  - She should look directly up at the ceiling without opening her eyes, then look down to the floor without opening her eyes, then look right, left, and in both diagonals.
  - When the therapist says, "Freeze," the child should stop her eye movement and point with her finger to a point in space where she ***feels*** her eyes are fixating.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Mental map of the eyes — **closed** eyes
  - Then she can open her eyes to confirm whether her eyes and finger are pointing to the same spatial coordinate.
  - Repeat procedure, looking left, right and diagonally.
  - Once easily achieved, ask her to roll her eyes clockwise and counterclockwise while the lids are closed.
  - Goal is to consciously feel the motion of the eyes and to be able to point to the spot in space where they are fixating

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Mental map of the eyes — **closed** eyes
  - Observe
    - Does the child make short cuts during rotations?
    - Does she show signs of distress by grimacing, etc?
    - How accurate is her eye-hand coordination?
    - Do the eyes move to the end of the range of motion?
  - If this is difficult, instruct the child to fixate with eyes open, then blink and hold the eyes in that position as long as she keeps her eyes closed

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Tracking
  - Tracking is fixating accurately on an object moving through space in various directions

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Tracking
  - Performance objectives:
    - Show accurate monocular or binocular sensory motor function, free of distress from the nose to infinity
    - Move the eyes freely and easily
    - Respond readily to cognitive demands

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Tracking
  - Performance objectives:
    - Be aware that control is mental, not reflexive
    - Point either eye at a target, monocularly or binocularly as the target is moved
    - Accurately fixate without overshooting or undershooting the target

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Tracking
  - Evaluation criteria
    - Stays on target without pauses or hesitation
    - Does not move the head or jaw or make facial grimaces
    - Moves freely and easily

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Tracking
  - Evaluation criteria
    - Does not show hesitation at midline
    - Does not undershoot or overshoot
    - Does not totally stop eye movement
    - Does not show double vision,

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Tracking
  - If the child shows any of these insufficiencies, reduce the demands
    - Movement of head or jaw or facial grimaces
    - Tearing or bloodshot eyes
    - Unstable fixation

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- AMBIENT/FOCAL relationships— SPATIAL PURSUITS
  - Patients give oral descriptions of visual judgements and interpretations from varying perspectives (egocentric and allocentric—- personal, peripersonal, extrapersonal)
  - If there are conflicting interpretations, he returns to the previous object to re-evaluate his previous observations.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- AMBIENT/FOCAL relationships
  - By this method of training in real space, the patient learns the visual ability to select figure from ground and to see the relationships, releasing figure to the ground without losing it from the field when he selects another objects as figure.
  - Socratic guidance to develop visual spaces can be used at the most basic level of training

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- SPATIAL PURSUITS:
  - Marsden ball hanging at nose level in the room
  - Patient stands two feet from the ball, facing the window, and maintaining good bilateral posture and balance
  - The patient describes orally what he sees making constant visual judgements
  - Visualization and imagery can also be incorporated by having the patient close their eyes and describe the visual scene he was just viewing.

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Sample questions:
  - What do you see?
  - What else do you see?
  - While looking directly at the ball, what do you see indirectly?
  - Where are these objects located?
  - How are they related?
  - How are they located?
  - What about their sizes?
  - How are they related to the ball?

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Sample questions:
  - Now look directly at the ____, and tell me what you see indirectly.
  - Where are these objects located?
  - How are they related?
  - Now look directly at the ____, and tell me what you see indirectly.
  - Where are these objects located?
  - How are they related?

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Swing the ball side to side, then:
  - Follow the ball.
  - What do you see? What else?
  - Where are they? What is happening to them?
  - How much of the area is moving?
  - Are there objects not moving?
  - Where are they?

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Swing the ball side to side, then:
  - Now look directly at the ____ and tell me what you see indirectly.
  - Where are they?
  - Is there any movement?
  - Are there any objects which are not moving?

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Do not ask a new question until the patient begins to run down his oral descriptions.
- The observations are noted as well as the patient's' ability to maintain fixation on the object of regard while discussing what he is seeing.
- Posture, weight bearing, central/peripheral vision abilities can all be incorporated.
- Can explore personal, peripersonal and extra personal space by varying person's distance from Marsden Ball
- Applications for the Infinity Walk, etc?

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Tracking
  - Flashlight tag
    - Hold one flashlight and give the other to the child to hold
    - In a semi-dark room, shine the light on the wall, ceiling or floor and move it in various directions
    - Ask the child to catch your light with their flashlight, moving it until it is on the same spot
    - Another variation is to chase the light with your hand or feet

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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Focus
- Goal
  - To help the child develop knowledge of how to increase and release monocular focus to maximum potential

201

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Focus
- Performance objectives
  - Show accurate monocular and binocular sensory motor function, frees of distress from the nose to infinity, for focus
  - Respond readily to cognitive demands
  - Be aware that control is mental and not reflexive

202

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Focus
- Evaluation Criteria
  - Says the target is clearly in focus
  - Turns the other eye toward the nose
  - Constricts the pupil

203

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Focus
- If the child shows any of these readiness insufficiencies, abandon the procedure and refer to developmental optometry
  - Inability/Unstable to fixation
  - Inability to move the eyes due to physical limitation
  - An eye turn
  - Inability to make the letters clear or blurry vision at far

204

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Focus
- Material, Opaque rock stick
- The aim of this activity to monocularly focus clearly on the target in maximum nasal position and as close as possible to the nose with both eyes open.
- Start with a septum blocking the view of one eye

205

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Focus
- Instruct the child to first hold the rock stick about 12 inches in front of one eye, focus on it clearly, release focus from the rock stick, then focus on a distance target, then go back to the rock stick
- While fixating on the distant target, the child should move the rock stick slightly closer to her eyes and then refocus on it.

206

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Focus
- Repeat several times.
- While fixating on the stick, she should make a gentle trombone motion toward and away, from clear to slightly blurred, and back to clear.
- The goal is to get it as close as possible with the letters clear.
- This rocking back and forth increases accommodation reserves

207

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Focus
- Ask which position (near or far) requires more effort to make her aware that she has to expend more effort to focus clearly at near distance than at far distance
- Repeat with both eyes viewing the targets

208

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Focus
- Observe
  - Are the letters out of sight of the other eye?
  - Are both eyes open and able to see at far distance?
  - Does the child move the rock stick forward and backward at the point of blur?
  - Are both eyes wide open?
  - Does she move the rock stick progressively closer toward her body's mid-line?
  - Does her other eye turn to the nose?

209

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Focus
- This is a very basic and foundational exercise for developing accommodation
- Any difficulty warrants a referral to developmental optometry to develop higher levels of accommodative function

210

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
  - Fusion is the mental combination of two images
  - Convergence is the movement of the eyes to point binocularly at an object so that fusion can occur
  - Two visual mechanisms are used to change fixation from far to near

211

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
  - The first mechanism is focusing- adjusting the eye to accommodate to the distance of an object
  - The other is convergence/divergence- adjusting the line of sight to the position of an object in space so that both eyes point to it

212

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
  - Convergence- eyes move towards each other as an object approaches
  - Divergence- eyes move away from each other as an object moves away

213

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
  - Goal
    - To help the child perfect fixation on an object moving toward and away from her and change fixation on objects in different positions in space with adequate biofeedback of eye movements

214

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
  - Goal
    - To help the child perfect fixation on an object moving toward and away from her and change fixation on objects in different positions in space with adequate biofeedback of eye movements

215

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
  - Performance objectives
    - Maintain bifixation in a tracking motion as the target moves closer and further away
    - Bifixate smoothly and immediately in a saccadic movement when looking from far to near and near to far
    - Immediately regain fusion with the target if it is lost

216

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
- Performance objectives
  - No leading or lagging of either eye
  - Work comfortably within the full visual field, very near and at arms length
  - Continually diagnose performance and adjust difficulty

217

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
- Evaluation criteria
  - Points each eye at the target
  - Releases and recovers fixation immediately
  - Fixates with both eyes, with one eye not turning in or out
  - Does not report diplopia

218

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
- Straw and Pointer
  - Materials: Straw and pointer
  - Begin monocularly to ensure accurate fixation
  - Hold the straw 12 inches in front of the nose along the z-axis
  - Emphasize peripheral vision awareness

219

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
- Straw and Pointer
  - Ask the child to hold the pointer by the ears and slowly move it from by the ear to inside the straw
  - Move the straw closer to the nose

220

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
- Straw and Pointer
  - Repeat binocularly, emphasize peripheral vision awareness
  - If at any time she sees two straws, move the straw slightly further away until one straw is seen
  - Once mastered along the z-axis, hold straw vertically along the y-axis

221

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- Convergence
- Straw and Pointer
  - Observe
    - Did the pointer enter the straw directly?
    - If difficult, can use larger straw or pointer.
    - If patient consistently misses the opening in one location, refer to developmental optometry to rule out eccentric fixation

222

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: OCULAR MOVEMENTS

- After basic visual convergence and divergence skills, optometric vision therapy may be indicated to develop the higher levels of fusion
  - Monocular Work in A Binocular Field
  - Bi-ocular Work
  - First, second, third degrees of fusion
  - Degrees of freedom between the accommodative and vergence systems
  - Should be considered in any patient with academic struggles or failure of the COVD Quality of Life Survey (more later)

223

VISUAL SPATIAL COGNITIVE PROFILE: DISCRIMINATIVE MOVEMENTS - DIGITAL MOVEMENT

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Pinchers: Are they able to use their fingers efficiently to manipulate objects?	Clothespins, bubble wrap, nuts and bolts, peg work, paper tear.	Necessary to develop the ability to accurately control and move objects with hands. Needed for stress-free, clear handwriting.

224

VISUAL SPATIAL COGNITIVE PROFILE: DISCRIMINATIVE MOVEMENTS - DIGITAL MOVEMENT

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Mental Map: Do they have an understanding of where their fingers are in space and how to control them?	Finger lifts, bead putty, shaving cream, finger paint, finger opposition, paper crumble.	Necessary to develop the ability to accurately control and move objects with hands. Needed for stress-free, clear handwriting.
Hand thinking: Can they use the tactile sense intelligently?	"What am I?" through touch, "Where am I?" to locate an object in the box.	Building more visual intelligence and visual mental imagery when asked to place it in a certain position and

225

VISUAL SPATIAL COGNITIVE PROFILE: DISCRIMINATIVE MOVEMENTS - DIGITAL MOVEMENT

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Grip: Do they use an adequate stylus grip with the thumb and index finger?	Penny pass, string ravel, pencil push, paper tear.	Necessary to develop the ability to accurately control and move objects with hands. Needed for stress-free, clear handwriting.

226

VISUAL SPATIAL COGNITIVE PROFILE: VISUAL THINKING

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Match: Can they discriminate between "same" and "not same"?	Match with blocks, cubes, pegs, geoboards, dot patterns, dominoes, and chips.	Necessary to develop the ability to understand information presented visually, such as maps, graphs, math concepts.
Recall: Can they create and hold a mental image?	Recall matching done with all media. Memory X's, Tachistoscope recall.	

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VISUAL SPATIAL COGNITIVE PROFILE: VISUAL THINKING

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Negative Space: Do they have an understanding of empty space?	Negative space done with rods, cubes, chips, and dots.	Necessary to develop the ability to understand information presented visually, such as maps, graphs, math concepts.
Separated match: Can they match orientation and spacing of blocks?	Matching designs in which blocks are not touching.	
Transpositions: Can they mentally manipulate and object or design?	Flips and turns done with all media.	

228

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Visual Thinking
  - Performance Objectives
  - Build a representation of a model in two-or three-dimensional space
  - Demonstrate visual knowledge of the model by accurately representing it according to instructions
  - Demonstrate visual knowledge by representing the model as it would look if it were flipped or rotated along one of the horizontal, vertical or transverse axes

229

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Visual Thinking
  - Performance Objectives
  - Demonstrate visual knowledge in a wide variety of media by representing the model with blocks, tiles, cubes, dominoes, chips, pegs, geoboards, and paper-drawn designs according to instruction
  - Demonstrate visual knowledge through recall (memory), speed of perception (flash), and distance (around the room), representing the model in another time or space

230

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Visual Thinking
  - Evaluation Criteria
  - Demonstrates accurate discrimination between "same" and "not same"
  - Visually places objects without having to manipulate them by touch
  - Makes visual adjustments before placing the pieces rather than using trial and error

231

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Visual Thinking
  - Evaluation Criteria
  - Demonstrates visual knowledge by making a design from pieces with proper orientation
  - Demonstrates visual knowledge of negative space and figure ground by selecting and orienting the missing piece based on its location in the incomplete design
  - Discontinue if the child is unable to recognize same or not same despite physical confirmation

232

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Visual Thinking
  - Can use inch cubes, parquetry blocks, chips, dominos, geoboard, pegboard, Koh's blocks, dot matrixes, etc

233

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Visual Thinking
  - Hierarchy of design from simple to complex
    - Parallel juxtaposition
    - Parallel off-center
    - Parallel hole

234

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Visual Thinking
  - Hierarchy of design from simple to complex
    - Tilted juxtaposition
    - Tilted off-center
    - Tilted hole

235

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Visual Thinking
  - Developmental Sequence
    - Stacking
    - Building a bridge
    - Matching
    - Separated matching
    - Pictures around the room

236

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Visual Thinking
  - Developmental Sequence
    - Building from outlines, with and without demarcations
    - Recall
    - Negative Space
    - Transposition along body axes
    - Perspective

237

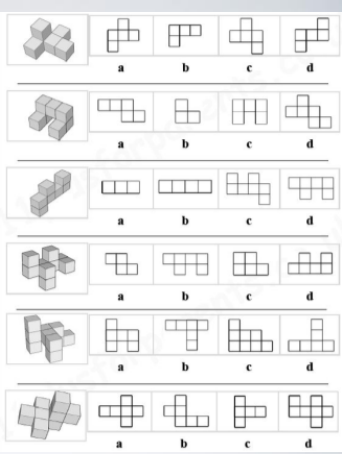
ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Visual Thinking
  - Developmental Sequence
    - Integration with other sensory inputs
    - Integration with time perception
    - Recognizing minimal clues (flashing)
    - Overcoming noise on the circuit
    - Receptive and expressive communication

238

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Spatial blocks – Visualization
- Can build in 3D and the patient can walk around the stack to determine which is correct



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ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: VISUAL THINKING

- Books such as Zoom and Re-Zoom are great picture books that can draw children into a world of visualization and spatial thinking.
- The increasing level of details helps illustrate the different spatial relations among objects.

240

VISUAL SPATIAL COGNITIVE PROFILE: VISUAL-AUDITORY

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Can they appreciate sounds in terms of pitch, duration, intensity, volume and pause?	Work with seeing sounds, syllable blocks, buzzer boards, word shapes. These activities help make the association between symbol and sounds by creating a mental construct.	Aids the ability to decode and comprehend, especially with new words.
Can they recognize and construct a mental image (seeing sounds) of the location of a specific sound or phoneme within a group of sounds?		

241

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: AUDITORY THINKING

- Approach that differs from that of traditional phonics in that it integrates auditory thinking with other thinking activities
- Assumes thinking precede language
- Activities develop the basic processes of hearing thinking and listening thinking, the prerequisites of acquired written or spoken language

242

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: AUDITORY THINKING

- Develop functional visual thinking before introducing auditory thinking activities
- Both involve laterality-directionality, figure ground, overlap, reversals, sequencing
- Auditory Thinking first uses concrete objects then written or verbal symbols to represent sounds

243

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: AUDITORY THINKING

- The activities develop the ability to discriminate variations in
  - Pitch (high or low)
  - Intensity (loud or soft)
  - Duration (length of sound)
  - Pause (length or time between sounds)
  - Elements (Components of sound words)

244

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: AUDITORY THINKING

- Goal: To help the child integrate visual and auditory thinking
- Performance Objectives
  - Increase and enhance visualization through hearing and listening
  - Coordinate vision with auditory experience
  - Recreate a sound by vocal imitation, clapping, buzzing, and graphic representation

245

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: AUDITORY THINKING

- Goal: To help the child integrate visual and auditory thinking
- Performance Objectives
  - Represent a model in two or three dimensions through hearing and listening thinking
  - Demonstrate visual knowledge of a model by repeating it or "Sounding it back" according to instruction

246

VISUAL SPATIAL COGNITIVE PROFILE: RECEPTIVE AND EXPRESSIVE COMMUNICATION

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Are they able to follow verbal instructions? Up to how many steps?	General Movement instructions, treasure hunt, floor matrix, direction with circles or a grid, hidden construction.	Necessary to be able to follow directions and give directions from someone else perspective.
Are they able to give verbal instructions?		
Are they ale to interpret direction given with spatial terms (near, far, top, bottom, right, left, etc?)		

247

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: RECEPTIVE AND EXPRESSIVE COMMUNICATIONS

- Goal: To help the child improve receptive and expressive communication through written and verbal language, gesture, drawing and construction
- Performance Objectives
  - Demonstrates the ability to give or receive specific, usable instructions to effect an outcome that can be confirmed by its inherent properties or by being matching with a hidden or visible model
  - Communicate and respond to instructions through sight, speech, hearing, reading, writing and gesture

248

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: RECEPTIVE AND EXPRESSIVE COMMUNICATIONS

- Performance Objectives
  - Perform receptive and expressive communication with patience and true two-way dialogue, demonstrating sensitivity to another communicator

249

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: RECEPTIVE AND EXPRESSIVE COMMUNICATIONS

- Evaluation criteria
  - Continuously diagnoses and adjusts performance within the basic-intermediate-advanced hierarchy
  - Demonstrates accuracy in only one modality or material
  - Demonstrates accuracy in either reception or expression (not both)
  - Deals with communication shortfalls cooperatively, not combatively, and tries to solve problems rather than assigning blame

250

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: RECEPTIVE AND EXPRESSIVE COMMUNICATIONS

- Floor Matrix
  - Communication: Verbal Language
  - Materials
    - 3x3 or 4x4 matrix with squares large enough for the child to stand in, drawn on a thin-thin-half sheet of plywood, sidewalk, or driveway or marked on the floor with tape or colored chalk

251

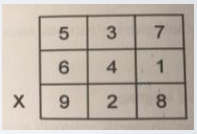
ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: RECEPTIVE AND EXPRESSIVE COMMUNICATIONS

- Floor Matrix
  - Communication: Verbal Language
  - Materials
    - 3x3 or 4x4 matrix with squares large enough for the child to stand in, drawn on a thin-thin-half sheet of plywood, sidewalk, or driveway or marked on the floor with tape or colored chalk

252

ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: RECEPTIVE AND EXPRESSIVE COMMUNICATIONS

- Floor Matrix
  - Instruct the child to stand in front of the matrix but not on it
  - Then give specific instructions to get from where he is to the final destination (a specific number, letter or symbol in the matrix).



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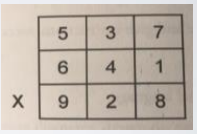
ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: RECEPTIVE AND EXPRESSIVE COMMUNICATIONS

- Floor Matrix
  - For example, if the child is standing at the X besides the square with a 9, and you want him to go to the square with a 7, you could say, "Take three steps forward and two steps to the right"



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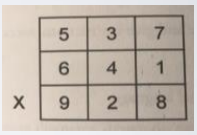
ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: RECEPTIVE AND EXPRESSIVE COMMUNICATIONS

- Floor Matrix
  - When successful, the child should be come the expresser, giving you instructions to get from one square to another.
  - Progress to a 4x4 matrix with numbers letters or symbols



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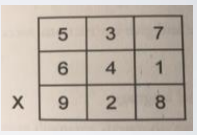
ACTIVITIES TO DEVELOP VISUAL SPATIAL KNOWLEDGE: RECEPTIVE AND EXPRESSIVE COMMUNICATIONS

- Floor Matrix
  - Progress to a matrix without symbols
  - "Taking 5 steps, go from 5 to 8, but avoid 4."



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VISUAL SPATIAL COGNITIVE PROFILE: VISUAL LOGIC

Visual Spatial Cognitive Profile	VSC Interventions	Why This Is Important
Do they understand conservation of number, mass or area?	Exploration of sorting and seriating, working with deductive reasoning. Attribute Blocks, Tooties.	Needed to develop the ability to solve visually presented problems logically, such as probability, inclusions, and inference.
Do they have an understanding of more, less, and equal?		
Are they able to systemically sort, seriate, or determine permutations?		

257

SPATIAL SKILLS AND MATH

- Many studies have found that high visual spatial ability is linked to better math performance.
- A $1 million pilot project supported by the National Institute of Child Health and Human Development shows how improving spatial thinking can result in better math skills.

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SPATIAL SKILLS AND MATH

- In this project, kindergarteners and first graders were randomly assigned to two after school intervention groups.
- In one group, children were asked to construct and copy designs made from a variety of materials such as Legos, pattern blocks and construction papers.

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SPATIAL SKILLS AND MATH

- The control group, on the other hand, was given a non-spatial curriculum.
- After about 7 months, the children in the first group made a substantial improvement in their math performance.
- They moved from the 30th percentile nationwide in numeracy and applied math knowledge to the 47th percentile. In the control group, no gain in math score was observed.

260

SPATIAL SKILLS AND MATH

- The most striking part of this experiment was that math was not taught at all. The instructors never specified any connections between the activities and math.
- Children's Spatial Skills Seen as Key to Math Learning. By Sarah D. Sparks http://www.edweek.org/ew/articles/2013/05/15/31learning.h32.html

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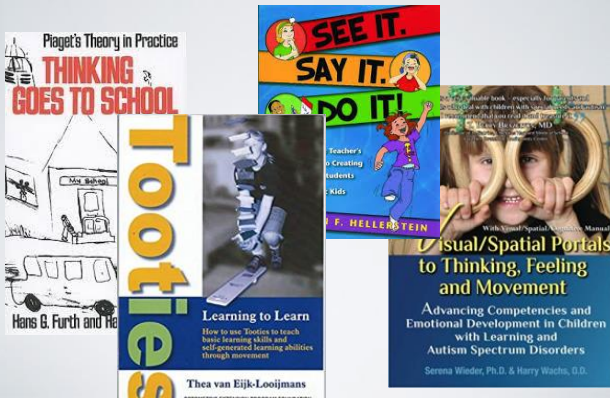
ADDITIONAL RESOURCES



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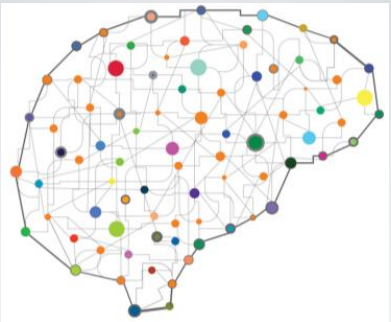

DEVELOPMENTAL OPTOMETRY'S ROLE

IN THE TEAM

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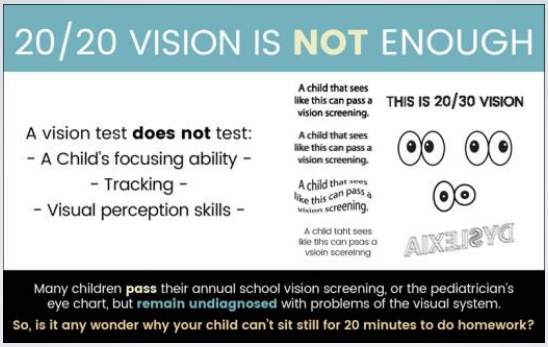

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WHEN TO REFER TO DEVELOPMENTAL OPTOMETRY

- Is vision helping or hindering development?
- Impaired Visual Acuity: less than 20/40 vision with correction (wearing glasses)
- Struggles in reading
- Double vision
- Eye movement skills that plateau in therapy
- Handwriting skills that plateau in therapy
- Toe walkers

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WHEN TO REFER TO DEVELOPMENTAL OPTOMETRY

- Does your patient ...
- seem smart in everything but school?
- avoid near work?
- complain of headaches and eye strain after reading?
- complain of blurring or double vision?
- squint or close one eye?
- turn or tilt head to one side?
- lose place often when reading?
- tend to reverse numbers, letters or words?
- have a loss of comprehension?
- get frustrated in copying from the board?
- have a short attention span and/or avoidance of near work?
- place head very close or far from reading material?
- seem excessively clumsy?

266

WHEN TO REFER TO DEVELOPMENTAL OPTOMETRY

- Vision Screening
  - Should check pursuits, saccades and convergence
  - Refer based on history and case presentation
  - RED/GREEN NEAR POINT OF CONVERGENCE
  - Evaluate the ability of the two eyes to work together, following a light that approaches their nose.
    - Materials:
    - Patient's Habitual Near Glasses
    - Pen Light & Red Green Glasses
    - Note the distance when two lights are seen, greater than 4-5 inches suggests Convergence Insufficiency and a referral to developmental optometrist is warranted

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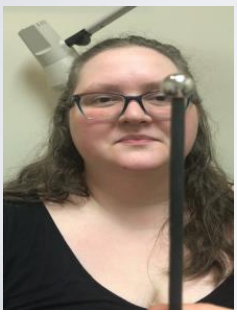
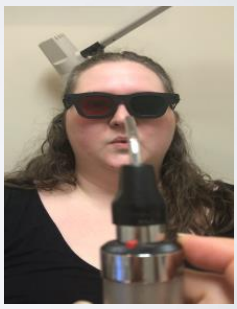
WHEN TO REFER TO DEVELOPMENTAL OPTOMETRY

- RED/GREEN NEAR POINT OF CONVERGENCE





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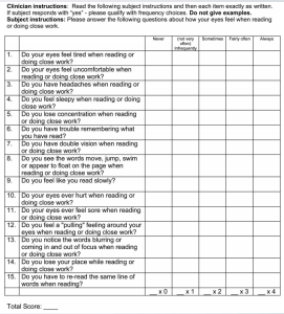
CONVERGENCE INSUFFICIENCY SYMPTOM SURVEY (CISS)

- Developed with over 20 years of NEI/NIH research: Published with CITT Study in 2008.
- Now using for research with attention and reading.
- Referral if:
  - Double vision or
  - Total Score > 16 in kids
  - >21 in adults
- https://wowvision.net/wp-content/uploads/2014/08/CI-Screening-and-symptom-survey.pdf



Clinician instructions: Read the following subject instructions and then each item exactly as written. If subject responds with "yes" - please qualify with frequency choices. **Do not give examples.**
Subject instructions: Please answer the following questions about how your eyes feel when reading or doing close work.

		Never	Infrequently (Occasionally)	Sometimes	Fairly often	Always
1.	Do your eyes feel tired when reading or doing close work?					
2.	Do your eyes feel uncomfortable when reading or doing close work?					
3.	Do you have headaches when reading or doing close work?					
4.	Do you feel sleepy when reading or doing close work?					
5.	Do you lose concentration when reading or doing close work?					
6.	Do you have trouble remembering what you have read?					
7.	Do you have double vision when reading or doing close work?					
8.	Do you see the words move, jump, swim or appear to float on the page when reading or doing close work?					
9.	Do you feel like you read slowly?					
10.	Do your eyes ever hurt when reading or doing close work?					
11.	Do your eyes ever feel sore when reading or doing close work?					
12.	Do you feel a "pulling" feeling around your eyes when reading or doing close work?					
13.	Do you notice the words blurring or coming in and out of focus when reading or doing close work?					
14.	Do you lose your place while reading or doing close work?					
15.	Do you have to re-read the same line of words when reading?					
		x 0	x 1	x 2	x 3	x 4

Total Score: ____

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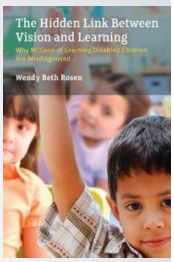
THE HIDDEN LINK BETWEEN VISION AND LEARNING

- The Hidden Link Between Vision and Learning by Wendy Rosen
- RESEARCHERS FROM OHIO STATE- 255 CHILDREN WITH IEPS
- 179 IDENTIFIED THAT NEEDED TREATMENT
- 69% OF THE CHILDREN WITH IEPS WOULD HAVE PASSED THE SCHOOL VISION SCREENING TEST
- TREATABLE VISION PROBLEMS!



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THE HIDDEN LINK BETWEEN VISION AND LEARNING

- The Hidden Link Between Vision and Learning by Wendy Rosen
  - CONVERGENCE INSUFFICIENCY 17.5%
  - ACCOMMODATIVE DYSFUNCTION 17.3%
  - STRABISMUS 11.5%
  - AMBLYOPIA 8.4%

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DORSAL STREAM DYSFUNCTIONS

- Effects of dorsal stream dysfunction will primarily include magnocellular driven functions:
  - Convergence insufficiency
  - Reduced accommodation
  - Reduced range of clear near vision

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DORSAL STREAM DYSFUNCTIONS

- Effects of dorsal stream dysfunction will primarily include magnocellular driven functions:
  - Reduced speed of focus change (accommodative facility)
  - Poor eye movement control – fixations, pursuits and saccades
  - Reduced fusional reserves
  - Related to a reduced functional field of vision

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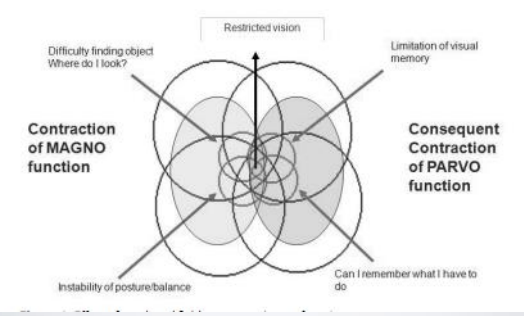
DORSAL STREAM DYSFUNCTIONS



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VENTRAL STREAM DYSFUNCTIONS

- Effects of ventral stream dysfunction will primarily include parvocellular driven functions:
  - Poor language and comprehension skills, leading to reduced performance in school as measured by school exam in reading, writing, and maths (SATs)
  - Reduced speed of reading
  - Poor fluency of reading, lack of intonation, boring to listen to

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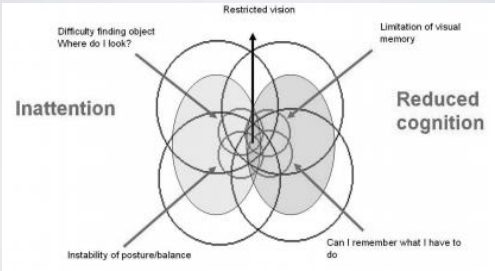
VENTRAL STREAM DYSFUNCTIONS



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TREATING VISION DYSFUNCTIONS

- Standard of Care for Non-Strabismic Binocular Dysfunctions

Box 3: The AOA Clinical Guideline for Management of Non-Strabismic Binocular Dysfunctions

Convergence Insufficiency:
In office vision therapy along with home therapy activities is the treatment of choice
Divergence Excess:
In office vision therapy focusing on diplopia awareness with operant conditioning technique to reinforce alignment.
Occlusion, over-minus lenses, base in prism for distance
Convergence Excess:
Plus lenses for near
In office vision therapy focusing on peripheral awareness and divergence at near
Divergence Insufficiency:
Base out prism for distance
In office vision therapy focusing on peripheral awareness and divergence at distance
Binocular Vision Dysfunction:
Lenses and prism generally ineffective
In office vision therapy focusing on both convergence and divergence ranges
Vertical Heterophorias:
Base down/Base up prism
In office vision therapy focusing on increasing horizontal vergence ranges

From Cooper, J., Burns, C., Cotter, S., Daum, K., Griffin, J., & Scheiman, M. Clinical Practice Guidelines. Care of the Patient with Accommodative and Vergence Dysfunction (2Eth ed.). St. Louis, MO: American Optometric Association; 2011:50-57.

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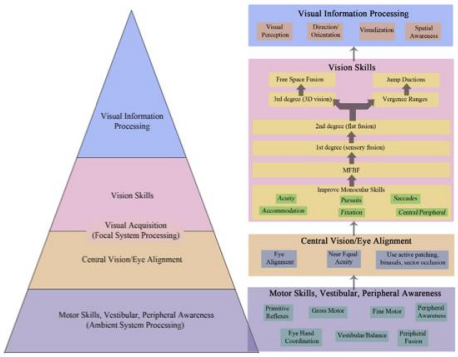
TREATMENT HIERARCHY



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ADVANCED TREATMENT OF VISION DYSFUNCTIONS

- Most vision problems need higher level treatment to achieve comfortable binocular vision over time
- All degrees of fusion should be addressed
- High level accommodative control should be achieved
- All visual skills should be integrated

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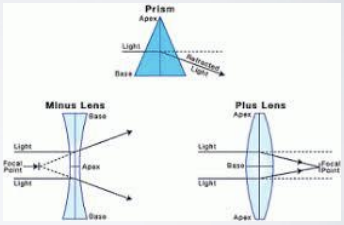
ADVANCED TREATMENT OF VISION DYSFUNCTIONS

- Spatial lenses
  - Plus Lenses
  - Minus Lenses
  - Yoked Prism



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ADVANCED TREATMENT OF VISION DYSFUNCTIONS

- Spatial lenses

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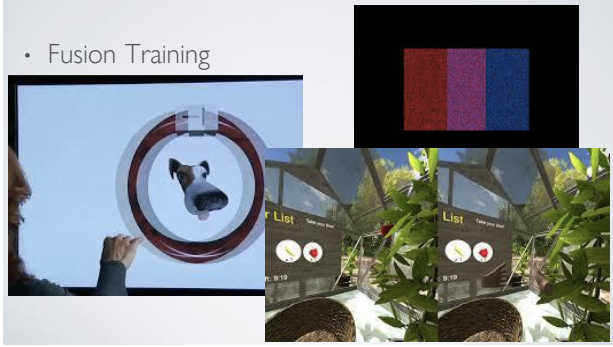
ADVANCED TREATMENT OF VISION DYSFUNCTIONS

- Fusion Training



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WHAT TO TELL PARENTS WHEN MAKING THE REFERRAL

- "I am identifying some issues with your child's visual system."
- "Your child needs a special type of eye doctor that assesses more the clarity of eye sight. These assessments are not part of a regular eye exam."
- "I will send your contact information to the specialized office and they will contact you to set up the appointment."

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FOR MORE INFORMATION AND DOCTOR LOCATORS…

- covd.org
- https://visionhelp.wordpress.com/
- oepf.org
- visionhelp.org
- thevisionandlearningproject.com

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kldavisod@gmail.com

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