Sensory Systems and Movement

This presentation integrates the two chapters:
1) movement and changing senses,
2) and proprioception and vision.

The presentation will discuss how the following sensory systems relate to performing motor skills:
- Visual System
- Auditory System
- Proprioceptive System
- Cutaneous System
Visual Development

Each eye achieves most of it grow prior to birth. At birth the child is hyperopic; light entering the eye focuses behind the retina (near sighted).

Eye’s cornea (grows from 2mm at birth to 12 mm at adulthood. In adulthood the corona’s shape changes in curvature to being less spherical.

Retina (rod and cones) is well developed at birth. During the first month of life the retina thins, cones begin to squeeze between the rod cells and macula become more distinct.

Macula (that part of the retina where rod cells are located) is mature around 8 months of life.

Ciliary muscles that control the eye and dilator muscles that control the pupil become functional at around 6 months of life.
Functions of Vision

Macula is responsible for peripheral vision. Rods are responsible for night vision. Cones are responsible for color vision.
Visual Traits

Visual Acuity:
- degree of detail that one can see
- Common way of measuring visual acuity is through static visual acuity tests
- Certain visual acuities have special significance. Some of these are:
  • 20/20 vision is considered normal vision
  • 20/40 vision in at least one eye is the vision required to pass the driving test
  • 20/200 vision or worse is the legal definition of blindness
- Static visual acuity improves the first 4-5 years of life.
- First 4-5 years of life, vision is of a very low quality but enough for many if not all the common tasks.
Visual Traits

Dynamic Visual Acuity

1. Ability to see detail in a moving object.
2. Ability of CNS to estimate the object’s direction and velocity and the ability to catch or hold the object on retina long enough to detect the object’s detail.
3. Improves from 6-20 years of age.
4. Most significant period of time of development seems to be between 5-12 years of age.
5. DVA declines after the age of 25.
Visual Acuity & Motor Performance

DVA is related to:

- Basketball field-goal shooting (Beals, et al, 1971; Morris & Kreighbaum, 1977)
- Ball-catching ability (Sanderson & Whiting, 1974 & 78)
- DVA improved during exercise (Millslagle & Cardwell, 2006).
Effects of Aging on Visual Acuity

Age-related macular degeneration (AMD) is a cause of loss of acuity in the elderly. Reflects the anatomical chances of the retina with age.

- Dry form of AMD (90% of AMD cases)
- Wet form of AMD (Break down of light-sensitive cells in the macula which effects central vision account for 90% of blindness in the aged)
Effects of Aging on Vision

Glaucoma

- Leading cause of blindness.
- Fluid entering and exiting the eye becomes plugged with cause pressure to rise in the eye.
- Usually affects peripheral vision then if left untreated central vision.
Changes in Vision

Most common cause of loss in visual acuity is cataracts.
- Eye lens become cloudy
- Causes of cataracts are smoking, alcohol use, exposure to sun’s ultraviolet rays.

After the age of 40 we begin to lose the ability to accommodate near objects (presbyopia).
- Distance vision is unchanged.
- Most people will need reading glasses or bifocal lenses
Diabetes and Vision

Diabetes causes the blood vessels of the eyes to hemorrhage (diabetic retinopathy). When the eye heals it usually tears the retina.
Binocular Vision

At birth both eyes operate independently (strabismus) but diminished by the 3rd month.

Coordinated eye movement, that is, the eyes move in unison is called binocular vision.

Macular images of eyes do not match; disparity between the macular is the primary cue for judging depth.

- Gibson’s visual cliff studies demonstrated that 1 year old children has organized depth perception.
- Depth perception is slow to develop and may be a reason by children bump into things.
- Depth perception usually matures by the age of 6.
- Depth perception is highly correlated with many sport skills such as basketball shooting, tennis, & football.
Field of Vision

Lateral and vertical peripheral vision
Lateral peripheral vision is 90 degree or 180 degrees when looking straight ahead.
Lateral peripheral vision is 47 degrees above and 65 degrees below when looking straight ahead.
The purpose of peripheral vision is to detect motion or movement.
Child’s peripheral vision is very limited.
Peripheral vision declines gradually declines after the age of 35 until 60 years of age. After 60, changes are more rapid.
Rapid changes after 60 are related facial changes that reduce the size of visual field (It’s time for a face lift!)
Eye Dominance

The ability of one eye to lead the other in tasks involving visual tracking and visual fixation.

The dominate eye can be assessed by the age of 5.

Hole in the card test is the most common way to determine eye dominance.

Unilateral dominance are people who are right-handed (left-handed) and right-eye (left-eye) dominate.

Crossed-laterals are people who are right-handed (left-handed) and left-eye (right-eye) dominate.

Unilateral dominant people seem to be better at wider variety of tasks than crossed-lateral people.

The best baseball hitters are cross-lateral people. Most professional baseball players are cross-lateral.
VISION PREDOMINATES OUR SENSORY-PERCEPTUAL SYSTEM

• We trust vision more than the other senses
• Two components
  – Central vision (width of your thumb)
  – Peripheral vision
Central & Peripheral Vision are two separate anatomical systems

• Based on neurophysiological evidence
• Both operate in parallel
• Central vision detects:
  – Static objects which are slow moving, responsible for recognizing object presences

• Peripheral vision detects:
  – Objects and High-speed movement around us, provides limb movement direction, and perceptually guides movements
Manual Aiming & Prehension Tasks

Manual aiming requires a person to move one or both arms over a prescribed distance to a target
- Consists of three phases
  - Movement preparation
  - Initial flight phase
  - Termination phase

Prehension is the act of reaching and grasping an object then object manipulation. (last stage differs from manual aiming task)

Vision plays different roles across the phases of an aiming and prehension
Role of Vision

Aiming Tasks
1) Movement preparation
   Vision is used to determine the direction and distance the limb must travel.
2) Initial Flight Phase
   Vision provides displacement and velocity information.
3) Termination Phase
   Just before the end of the movement when target is hit, one can use vision to make simple movement corrections.

Prehension Task
1) What a person does after the object is contacted is an essential component of prehension!
2) Vision provides information when the hand and fingers begin to form the grasp.
3) Vision provides information so the hand can make modifications as it approaches and grasps the object.
VISION ISSUES

1) How do the eyes and hands work together when performing a aiming or prehension task?

2) Is their a minimum amount of time needed to make a correction when hitting the target or during grasping?

3) Should I use one eye or both eyes during aiming or prehension tasks?

4) What role does central and peripheral vision play in performing aiming and prehension tasks?

5) As I move my arm to the target, what type of information does one rely on to make an accurate grasp?
How to the eyes and hands work together?

• Point of gaze is measured during eye fixation and then calculated to determine the timing/location of the hand movement.
  – Point of gaze occurs 70 ms before the hand begins to move from their starting position.
  – Point of gaze arrives at the target 450 ms before the hands arrive so movement corrections can occur.

• In summary, vision precedes and guides the hand before it moves to the target and is needed to make movement corrections at the end of the movement.
Eye Recorders
IS THEIR A MINIMUM AMOUNT OF TIME NEEDED TO MAKE A CORRECTION?

Lights on and light off technique is usually used to determine the time of correction.

- Best estimate is we need at least 100 to 160 msec of visual information for simple manual corrections.
- This issue become apparent when we use visual feedback to correct our movement such as in catching a ball or hitting a ball.
  - If ball speed is too fast or distance the ball travels is too short then movement corrections is dependent on initial hand position.
Should I use one eye or both eyes?

• Monocular versus binocular vision
  – Motor control system operates more effectively and efficiently when it receives information from both eyes.
  – Accuracy and efficiency of movements decrease as the distance to the object increases.
  – Monocular vision causes one to underestimating distance to the object (e.g. shooting with one eye open in hunting).
Role of central & peripheral vision related to prehension tasks.

- Peripheral vision seems to affect the transport phase (reaching for the object) but not the grasp.

- Central vision provides information specific to the object.
  - But if you block central vision the transport and grasp phases will be affected.
What type of information is being used?

- *Optical variable tau is Time to contact* or distance based information.

- Tau is amount of time remaining until the object contacts the person (or vice versa) from a specific distance.

- Tau is predictive function which allows action initiation and object contact to occur *automatically* at a specific time to contact regardless of the speed of the object and person.

  - *E.g. breaking to avoid hitting a car……process time needed by visual information to brake rather than knowledge of how much distance there is between you and oncoming car.*
How do we measure one’s vision?
Temporal Occlusion

Amount of time a person requires for visual search. Experimenter determines the time period of interest as they relate to the skill performed. Experimenter stops as a predetermined time point during the action. Athlete, student, or client makes a response as quickly as possible.
Setter is setting to??????
Event Occlusion

Used to identify the specific information a person uses to make the required response.

Parts of the movement are masked so that the observer cannot see selected parts.

If a person performs worse without seeing the part the movement, then the part is an important visual cue used to perform the movement.
Event Occlusion
Vision & Performing Motor Skills

• Handwriting
• Locomotion
• Contacting objects
• Avoiding objects
• Catching
• Hitting
VISION AND HANDWRITING

Write your name with vision on lined piece of paper then write your name with your eyes closed.

1) Vision helps to control the overall spatial arrangement of words on a horizontal line.

2) Vision helps one produce accurate handwriting patterns, that is, stroke pattern and lettering.
Vision helps maintain one’s dynamic balance during locomotion

Walk down the hallway with your eyes open then walk with your eyes shut.

1) Peripheral vision is key player.
2) Peripheral vision detects visual cues in environment by assessing optical flow patterns (light-object reflection)
3)
Locomotion & Vision
Vision & Contacting Objects

As you walk rapidly down a hallway attempt to make contact with a target placed on the floor.

1) Visional information is used to determine the amount of time it will take to contact the target (time to contact or Tau)

2) Tau is used to make stride-length adjustments during the last few steps to correct any errors.

3) Tau is a quality we possess that is not dependent on experience.
Long Jump Study

• Analyzed stride-length changes as the athlete approached and contacted the take-off board for a series of 6 jumps.
Vision & Avoiding an Object

Make to two lines of students in the hallway. Have each line face each other. Have each line begin walking toward each other. The objective is to avoid contacting the students as they walk toward each other.

1. Vision provides the human with body scaled information (size of the object) that they use to avoid an oncoming object.
2. Vision provides a predictive information that specifies the type of step-pattern alternation that is needed.
Avoiding Objects As we walk

- If one is to maintain footspeed while avoiding an object three time periods are critical
  - Recognize that an object needs to be avoided*
  - Adjust the foot
  - Turn the foot to avoid the obstacle

*The most critical period is recognizing that the object needs to be avoided

Implication are a person must recognize objects sufficiently early to allow appropriate movement adjustments.
Virtual Reality Training

Compared stepping over real or virtual objects on a treadmill as an intervention strategy for poststroke patients.

– One group was the real obstacle training group that wore a gait belt and stepped over foam obstacles in a hallway.
  
– Second group were placed in a harness, walked on treadmill with head mounted display that showed images of same objects as in real obstacle trained group

Virtual trained group balance, velocity, cadence, strike length, and obstacle clearance showed the greatest improvement.
Vision & Driving
VISION AND JUMPING FROM HEIGHTS

- Tau triggers specific preparatory actions so that the jumper can land correctly.
- EMG studies have indicated the relationship between tau and rectus femoris activity, regardless of the height of the jump.
- Vision controls the onset of the muscle activity required for jumping from different heights.
Vision & Catching

Catching
1) Involves a moving object
2) Grasping the ball is the end movement of catching

Prehension
1) Involves a stationary object
2) Prehension involves manipulation of the object
Three Phases of Catching an Object

On initial ball flight, no arm action is seen. About 25 to 80% of ball flight, elbow flexion and finger extension occurs slowly. At about 50% to time the ball is caught, the hand withdraw and become sptatially positioned. Shortly before the catch, fingers become positioned. *Successful catchers had their hands and fingers ready to catch the ball earlier than unsuccessful catchers.
VISION AND CATCHING

• Visual contact is needed during the initial part of flight and period of time just prior to contact with the hand(s)
  – Only the first 300 ms of flight is needed to determine direction & distance.
  – Only the last 200-300 ms before hand contact is critical.

• Viewing the object between these two time periods is not critical to catching

• Performers visually sample the ball flight characteristics to obtain up-to-date information they need to catch the ball (snap shots)

• Optical variable tau is involved in solving the time to contact problem in catching
  – An approach object visual size increases (looming) which the visual system uses to determine when collision with the object will occur.
DOES ONE NEED TO SEE THEIR HANDS TO CATCH AN OBJECT?

• Smyth & Marriott study of seeing or not seeing their hands..
  – Seeing their hands were more accurate

• What influence does experience have???
  – Experienced catchers do not need to see their hand.
  – Lowly skill catcher do need to see their hands throughout the flight
VISION AND HITTING

1. One can see the ball only to the point at which the swing is made (Hubbard & Seng) not to the point of contact.

2. Success in hitting or striking is related to tau-base strategies:
   - Batters synchronize the start of their step to release of the ball.
   - Successful hitter’s duration of the swing to swing was consistent.
   - Duration of the swing adjusted according to the speed of the oncoming pitch.
   - Successful hitters use the same visual tracking pattern and had a consistent stance to prepare for the pitch.
   - Head position changed less than 1 degree across all types of pitches.
   - All adjustments and decision to swing is triggered by visual information that occurs in the first 500 msec of ball flight.
   - Last 2/3 of ball flight the striker can only make slight racquet or bat changes.
Tracking a Visual Object

Visually retaining the object on forea of the retina during flight.

Two eye movement:
- Smooth pursuit (matching speed of the object with eye movement speed) primarily used to track an object moving a slow speed.
- Saccadic eye movement (detects and corrects differences between the objects location and eye fixed on the object) primarily used to track an object moving at fast speed.

Infant is not capable of tracking an object with their eyes; only can track objects with hand movements.

By 5 or 6, children can track objects in a horizontal plane.

By 8 or 9, boy or girls can track balls that travel in a arc.
Coincidence Anticipation Timing

CAT is usually measured with Bassin anticipation timer. Involves tracking an object to a target area then makes a motor response coincide with the arrival of the object.

Many factor affect CAT:
- Speed, viewing time, gender, age, and object predictability.

Kuhluman and Beitel (1997) found that practice related to sport participation is a better predictor of CAT than is age.

We make more errors at slow and fast speeds (Haywood).
- Slow balls are not the easiest balls to catch.

Boys are more accurate than girls (Millslagle, 2005).

Dynamic Visual acuity (tracking) is lowly related to coincidence (Millslagle, 2001 & 2004).

Experienced players involved in object control (eg. Softball) have higher level of CAT then inexperienced players (Millslagle 2000)

Individual CAT performance is greatly effected by decreasing stimulus speeds as compared to stimulus speeds that increase or remains constant (Millslagle 2006 & 2007)
Visual Training

• Experimental evidence is lacking about the effectiveness of general vision training to improve sport performances
  – Sport Vision
  – Eyeroics

• Many common visual functions do improve but research has found that Visual ability is sport specific.
  – Visual training exercises should be sport specific.
Proprioception

Attaching meaning (perception) to our sensations from our limb, body, and head movements and positions.

Commonly overlooked because vision seems to dominate but provides sensory information about speed, direction, location in space of the movement.
## Proprioception

| Movements where feedback can be used (closed loop control), proprioceptive feedback plays a significant role in controlling movement. | Movement where feedback is available but can be used (open loop control), proprioception plays a limited role to control fast, ballistic movements. |
Neural Basis of Proprioception

We receive information from afferent neural pathways of CNS that begin in proprioceptors located in our muscles, tendons, ligaments, and joints.

These specialized mechanoreceptors provide us with uninterrupted knowledge about the position of body parts relative to each other and our general body orientation in space.
Examples

Dancers use proprioceptive feedback to sense the changing and relative positions of their limbs in space through the routine.

Baseball pitcher can use proprioceptive feedback to determine how quickly his throwing limb is moving through the wind-up phase of the pitch.
Types of Proprioceptors

Muscles spindles

Golgi-tendon organs (GTO)

Joint receptors
Muscle Spindles

Attached to all somatic muscles.

Considered to be the most important mechanoreceptor.

Detects changes in length and tension of the muscles essential to being aware of limb position and movement.
Rapid Correction of Limb Position

(A) The muscle spindle is innervated.

(B) A sudden increase in load lengthens the extrafusal muscle and results in muscle spindle firing and transmission of sensory impulses to the spinal cord.

(C) Impulses are sent back to the muscle and causes it to contract and elbow joint returns to original position.
Golgi Tendon Organ

Positioned at the distal and proximal myotendinous insertion of skeletal muscle.

Primarily responsible for signaling muscle tension and force of contraction.

Fires very quickly and is a protective mechanism.

Provides moment-to-moment changes in movement.
Joint Receptors

Joint capsules and ligaments of all synovial joints are supplied with proprioceptors.

Joint receptors is a collective term because not all joints contain the same type of proprioceptors.

Joint receptors are golgi-type endings; Ruffini endings; Paciniform endings; and free nerve endings.

They function as limit detectors that signal extreme joint positions and as a protective mechanism.
INVESTIGATING PROPRIOCEPTION

• Surgical deafferentation

• Sensory polyneuropathy patients

• Nerve block technique (Temporary deafferentation)

• Tendon Vibration technique
ROLE OF PRIOPRIOCEPTIVE FEEDBACK

- Affects movement accuracy
- Affects the timing of the onset of motor commands
- Affects coordination of body and limb segments used in the movement
  - Spatial-temporal coupling between limbs & limb segments (difficulty in replication of movements)
  - Postural control (more sway)
  - Ability to adapt to movement situations
Auditory System

Prenatal hearing occurs during the last few months of pregnancy. At birth, the newborn can hear. Auditory development during the first 3 months of life is related to the voice of parents. Usually, associate with the parent that provides food and comfort. At 4-7 months, toddler can recognize tone of the voice which critical for language development. At 7 months toddler recognize their name and first attempt of speech occur. At 8-12 months, toddler produces recognizable sounds. 1-2 years of age, infant recognizes and respond to commands. If any of these milestones are not demonstrated….hearing impairments may exist. If hearing impairments are not recognized they will effect language and speech....
Cutaneous System

Receiving information from sensory receptors located at the body’s surface, the skin.

- pressure
- coldness
- warmth
- pain

Some work fast (Meissner’s and Pacinian corpuscles)

Some work slowly (Ruffiniin’s endings and Merkel disks)
Facts about Cutaneous System

First system to develop fully in humans.
Tactile sensory information helps control movement
- The receptors in skin provide information by detecting skin stretch & joint movement
- Tactile sensory information is related to movement accuracy, consistency, and force adjustments for ongoing movements
- Assist in estimation of movement distance

Early in life, sensitivity to tactile stimulation is greatest in the parts of body that are used to explore the world.
- e.g., Mouth, lips, and tongue in an infant

Being active and play are very important role in development of haptic perception
The End!