How We Move…

Ecological View

Motor Pre-planning & Initiation → Perception of Self in Space → Sensory Input → Movement within environment

“Sensory Processing”

“Motor Processing”

“Central Processing”

Somatosensation

Vestibular

Sensory Macular

Polymodal
Sensory Balance Processes

- **Vestibular**
  - Angular (turning) movement
  - Head about spinal cord
  - Linear movements
  - linear accelerations
  - Head tilts
  - Reflexes

- **Somatosensory**
  - Joint perception
  - Pressure and tactile perception
  - Body position in space (relative to gravity)
  - Haptics

- **Vision**

Human Vision: A Tail of Two Systems

- **Vision**
  - Macular
    - Color vision
    - Reconstruct world
  - Peri-macular
    - Night vision
    - Motion detection

Macular System

- Cerebral Level
  - Fovea
  - CN II,
  - Optic Chiasm
  - Projections to Occipital Lobes
- Reconstruct world
  - Objects
  - Events
  - Space / depth
Eye Movements and Foveal Vision

- Gaze
  - Identify and place visual distinctive feature on fovea

Peri-Macular Vision

- Rod cells
  - Night vision
  - Motion detection

Perspective and Depth Cues

Peri-Macular System

- Very sensitive to movement / optical flow and low light.
- Optical flow: Surround moves systematically with eye or head movement.
  - Example: “Expansion” optical flow

Scene Reconstruction

Laminar Ocular Flow:

- Significant portion of scene moves in one direction - movement cue
  - Top laminar flow associated with eye movement
  - Bottom laminar flow affected by fixation point (head movement)

“Top Down” process of expectancy set
How We Move...

Video Clips

Binocular Peri-Macular Cues

Binocular Peri-Macular Cues

Binocular Peri-Macular Cues

Binocular Peri-Macular Cues

Near Objects and Self Motion
Binocular Peri-Macular Cues

No Retinal Disparity for Distant Objects

Implication:
- Loose Depth Cues
- Loose self movement cues

Reactions to Loss of Visual Flow

- Visual destabilization results in varying reactions from collapse to height imbalance or height disorientation
- Common to all is a sense of vulnerability / danger

Visual Flow and Movement

- When we are standing “still” we are not really still
  - Small body movements reflected in visual flow
  - 20 minute arch minimum required for peripheral retina to detect motion
  - When objects are close (3 m for example), normal sway of 2 cm generates movement induced visual flow

Height Imbalance

- Counter measures:
  - Fixate on near objects
  - Suppress reliance on self movement induced visual flow,

Visual Flow and Movement

- As eye–object distance increases, sway must increase to induce visual flow
  - At 15-20 meter of eye-object distance, self sway must be greater than 10 cm to induce visual flow
  - This can approach or exceed the limits of stability, depending on posture.

Height Imbalance

- Counter measures:
  - Rely on other senses (vestibular, proprioceptive and haptic),
Height Imbalance

- Counter measures:
  - Develop motor skills (strength and coordination) to respond to ambiguous or misleading visual cues.

Physiology of Postural Control and Heights

- Confidence despite ambiguous sensorium
  - Wide range of inter-individual but narrow range of intra-individual variability.
  - This would suggest intolerance vs. tolerance in normal subjects is due to different psychological responses to heights or danger.

Thermals

Air Sickness

- Open versus Closed Loop Movement...

Space shuttle and football

Confident Expectancy
How We Move…

Ecological View

- Perception of Self in Space
- Motor pre-planning & initiation
- Sensory Input
- Final common pathway
- Movement within environment
- Vestibular
- Somatosensory
- Visual

Fear Reactions

- Points
  - Vestibular system is a small but important part of our system of balance control and movement.
  - Vestibulopathy may cause dizziness, but not necessarily vertigo
  - Roll of sensory information in motor planning varies by situational context
    - Confident Expectancy versus Fear