# Vision Proprioception and Motor Imagery

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Today going to talk about vision proprioception and motor imagery and their roles in locomotion. Relating how we use vision proprioception or optic flow as a visual guidance system providing feedback about the environment so adjustments in walking gait can be modified in order to maneuver through the environment and mental imagery to help stimulate a given motor action that begins the motor patterns needed for locomotion.

I use Skeffington's Venn diagram as a platform and will be speaking in regards to the "Where is it?" circle.

Streff said many years ago, "When vision works well, vision leads and guides in all one does. When not working well, it interferes."

I submit that walking and locomotion begins with motor imagery and vision proprioception.

Walking is a complex task that involves both the central and peripheral nervous systems, which generates and controls the dynamic instability of movement in an unstable environment in order to produce the propulsive force needed for forward the progression of the center of gravity.

A normal gait is the successful integration of both sensory and motor functions to produce a series of rhythmical, alternating movements of the trunk and limbs to move through the complex environment.

Efficient traversing through space requires spatial orientation, balance and gaze stability. The observation of a how person walks and maneuvers through their world affords us clues as to how they have integrated their cortical and sensory neurological systems.

**Motor Imagery**: The imagination of a motor task of movement without actual movement execution. It is the ability to accurately form an internal model of motor control which provides stability to the motor system by predicting the outcome of movements before sensorimotor feedback is available. Without motor imagery, the child has to rely on their actual motor ability to make decision on action representation. In other words, move first then assess the movement.

Motor imagery is developed during childhood and it reaches an asymptote during adolescence and is developed through kinesthetic imagery which is how it feels to perform a task, including the effort and forces perceived during movement. Motor imagery is influenced by executive function.

**Vision Proprioception**: this involves the visual feedback when moving through an environment or if the environment is moving.

Visual Proprioception – Optic Flow

**Optic Flow**

Optic flow is a constantly changing optic array of light moving over the retina as a person moves through space. This is a spatial-temporal coordinating effort in a constantly changing environment. Optic flow provides information as to the direction heading when moving towards a target and reflects the translations and rotations of the head but not related to eye movement.

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The changes in the flow pattern over time are critical for indicating the direction of movement or heading direction and defined with respect to the head's movement through space.  This array also provides cues about the structure of the environment.  The perception of movement is such that flow field that is farther away does not seem to move while the flow field of nearer objects will move much faster.

In respect to the heading direction there is a symmetrical optic flow field present and when movements are made to either the left or right of the target direction, the flow field will be asymmetrical indicating going away from the target and there will be a redirection towards the object target.

Then there is the Tau of movement.  The Tau is spatially measuring how the action (movement)gap is changing.  This whole movement is then a blend of space and time.

**Neurological Systems**

The neurological systems for both motor imagery and vision proprioception include the dorsal stream, basal ganglia, cerebellum, supraspinal nuclei and spinal alpha motoneurons.

**Dorsal Stream**

The neurological systems important to begin with the visual cortex, in the sighted person, traveling through their environment include cortical areas that make up part of the dorsal stream, the "where is it" system, the cerebellum, the supraspinal nuclei and finally the spinal alpha motoneurons.

The dorsal stream affords the most sensitive and reliable information for balance and movement important for moving through space.

Motor imagery seems to begin in the parietal cortex area and moves forward through the cortical motor areas and may even be in the prefrontal cortex.

Vision proprioception begins in the V1 area then information is transmitted to V5 and from here up to the posterior parietal cortex and then to the prefrontal cortex.

The input from vision plays a major role to control body balance, posture, and movement.

The role of visual proprioception is to monitor optic flow through the optic flow field.  The spatial motion over the retina or the changing angular positions of points of space in the environment that pass over the retina that result from movement through the environment.

The cortical place where optic flow is thought to be integrated is in the area of V5.  The reasons are that the visual receptive field response is very large in comparison to the receptive field in V1.  In addition, when there is an optic flow field presented to the individual there is an increase in the BOLD (blood oxygen level as determined with fMRI) to indicate that there is a substantial amount of activity in this area.

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V5 has a reciprocal inhibition relationship to vestibular cortical areas where input from vestibular affects the responses and the vestibular cortical areas are affected with input from V5.

V5 also receives input from mechanical cervico responses in the neck area. This was determined from observations in individuals that had a significant reduction or total loss of function from vestibular. So, the reality is that V5 does receive input from the mechanical receptors in some capacity.

**Prefrontal Cortex**

The prefrontal cortex receives information through the dorsal stream regarding positions in space and construction of the environment. The prefrontal cortex is responsible for the cognitive control of movement, to include the planning of movement, attention, problem-solving, error-monitoring, decision making, social cognition and active short-term memory. This area helps to determine which groups of muscles are to be used in order to navigate through the environment.

The prefrontal cortex is actively involved in the walking process because, again with BOLD fMRI technology, there is a significant increase in the oxygen levels during the walking action.

The Cerebellum nuclei helps to support posture, and eye movement and helps to correct ongoing movements through the somatosensory feedback.

Cerebellum

This structure supports posture, gait and eye movements. It is related to coordination and adaptation of movements. This also corrects ongoing movements through somatosensory feedback.

**Supra Spinal Centers**

The supra spinal centers include: Red nuclei, reticular formation and vestibular.

These areas are also easily subjected to stroke, brain tumors, TBI and ABI, cerebral palsy and cerebellar ataxia.

The supra spinal centers are responsible for initiating and modifying the features of the basic walking rhythm: reciprocal arm and leg swings; stride; step; weight shifts and cadence. They are also responsible for stabilizing and coordinating the upright walking movement to allow the effortless coordinated movement through a dynamic environment.

The red nucleus gets its information from the cerebral cortex and cerebellum. The red nucleus facilitates the flexor movements in the contralateral upper limbs – arm swings.

The reticular formation receives information from many areas but with its role in voluntary movements the major influence comes from the cerebral cortex. The pontine facilitates the extensor movements and reduces or inhibits the flexors and the medullary area is the opposite, facilitating the flexors and inhibiting the extensors.

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The vestibular nucleus is associated with balance and equilibrium. This facilitates the extensor muscles in the ipsilateral limbs and influences muscles of the head, neck, trunk and proximal parts of the limbs.

**Spinal Motoneurons**

Spinal motoneurons, also referred to as the spinal alpha motoneurons, are the final common path for all the voluntary movements of the head, neck, trunk and limbs. They innervate muscles either individually or in groups. All movements require the activity of these lower motor neurons in various parts of the spinal cord and the number of units involved varies depending on the movement.

It is thought that these spinal motoneurons may provide some autopilot type of walking because they show activation patterns in two major bursts – one on heel strike and the other on toe off. And, these patterns exist without cortical influence.

Motor imagery and vision proprioception have an influence all the way from the top to the bottom.

The normal walking gait has a slight side-to-side movement due to weight shifts, stance etc. This side-to-side movement helps with spatial orientation and target triangulation, much the same way that a cat will move from side-to-side when ready to pounce on a target. Optic flow feedback helps keep this movement to a minimum.

What if vision proprioception was inefficient or less dominant and the VOR or COR is more dominate? Could there be a need to have additional motor overflow to stimulate the optic flow feedback system?

What if there were poor motor imagery or visualization skill? Would there be more non-purposeful motor movement or motor overflow observed?

But what if there is a binocular vision problem like strabismus, CI or ocular motor dysfunction? Could there be a need to have a larger side-to-side motion for spatial orientation to achieve target triangulation and there is a deficiency in the optic flow feedback system?

What are abnormal walking gaits? "Any change in the symmetry of the rhythmical, alternating movements of the trunk & limbs reflected in the gait period durations.."

So, what is an abnormal walking gait? An abnormal gate is any change in the symmetry of the rhythmical, alternating movements of the trunk and limbs reflected in the gait period durations.

Some of the walking gaits that may be identified as related to vision proprioception include: Trendelenburg, Ataxic, Idiopathic Toe Walking (ITW), and Cerebral Palsy.

The Trendelenburg gait is also referred to as the waddling gait. The upper torso demonstrates a large side-to-side sway during walking. The common symptoms include having weak abductor leg muscles and abnormal hip posture affecting the leg swing. This allows the upper torso to move in large swings.

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Suppose a person has strabismus or other binocular condition and requires a larger side-to-side motion for efficient target triangulation and spatial localization? Is it possible that this accentuated movement, over time, could create additional stresses on the hip muscles and joints and cause them to fail?

Ataxic or spastic gait is described as having a larger step width and the arms swing out and away from the body and the movements are jerky and unsteady in a staggering type movement and proprioception deficits.

Suppose a person has poor vision proprioception and motor imagery? Is it possible that a wider base is required to rely on heightened mechanical proprioception for balance and orientation? Is it possible that the spastic type movements are, in part, related to poor motor imagery?

Is it possible that ataxic gait develops, in part because of poor vision proprioception, a deficiency in the optic flow feedback monitoring their view of the world?

Idiopathic Toe Walking (ITW) has no formal or official definition. It is classified as an intermittent toe-to-toe walking gait pattern with a child who walks mostly on their toes. They can walk with a heel strike when asked to or when distracted. This condition is always bilateral and symmetrical. This is also confused with true toe walking.

The diagnosis is one of exclusion, there is no known cause and there are no significant signs of neurological or orthopedic conditions. It is also referred to as a idiosyncratic habit. This condition is manifested after 18-36 months of age. Up to this time the toddler is demonstrates some heel strike toe off gaits and some toe to toe gaits, but after this period the toddler develops a heel strike waking gait. If a toe to toe gait persists then its considered ITW. This is present in the population with more boys than girls.

These persons also have significant developmental delays in speech and language, about 24% to 54% have an average delay of about 14 months.

There are gross motor and bilateral integration issues and fine motor control difficulty; bilateral integration issues; visuomotor; binocular dysfunction; constricted performance fields (tunneling)

This walking pattern is more prevalent in the pervasive perceptual disorders such as: autism spectrum, developmental coordination, obsessive compulsive and ADHD populations. It is shown that these behavior patterns have deficits in motor imagery showing with developing an internal model of imagined movements. They also demonstrate poor optic flow feedback.

Suppose then that a person has poor motor imaging, is it possible that they would use actual motor ability to make movement decisions? Would they be the ones who act first and then process later?

Suppose they had poor vision proprioception, is it possible that they would require motor overflow feedback for spatial orientation and balance?

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**Treatment procedures**

Any activity that includes walking and general movement through space stimulates vision proprioception, such as the infinity walk, walking rail, walking with mirror and others.

Any activity that involves head movement helps to stimulation of the VOR and COR may assist in the controlled inhibition between vision proprioception and will include the belgaue bean bag toss, doll's eye procedures and body rolls and head rolls.

Any activity that includes visualization and kinesthetic imagery, the feeling of effort and energy, prior to making a movement during the motor activity will help develop motor imagery.

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Thank You.

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