SAPIENZA
UNIVERSITÀ DI ROMA

Cervical reflex

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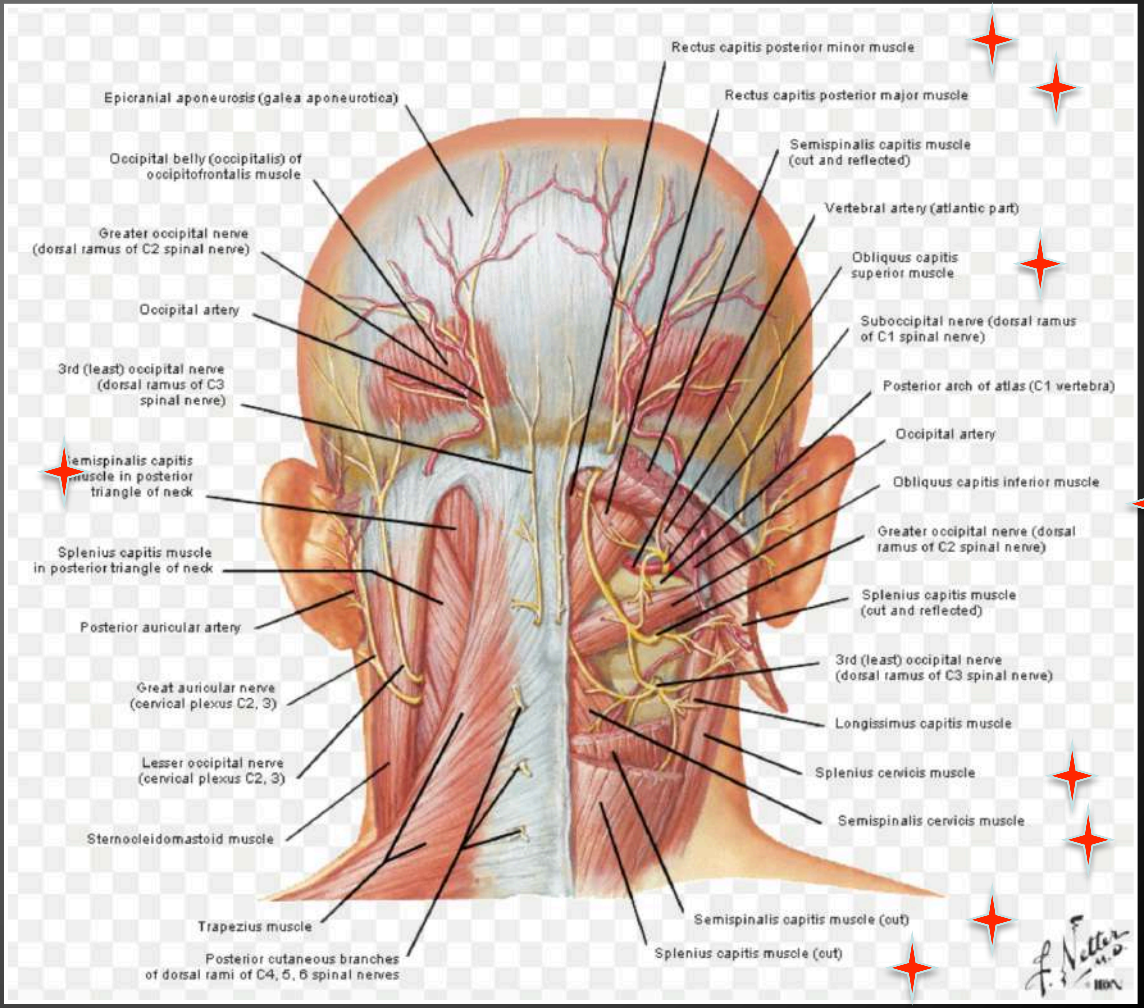
The development of the neck in vertebrates allows the individual to rotate the head independently of the trunk in both static and dynamic conditions.

On the other hand it is sensitive both to the force of gravity which tends to flex the joints and to the oscillations of the trunk.

This makes vestibular inputs unreliable.

The stability of the head is ensured by the constant contraction (postural tone) of the antigravity muscles of the neck.

The main muscles of the neck are the small and large posterior rectum, the small and large oblique, the semispinal of the neck and the head, the transversus of the neck, the splenium of the head and neck.



The antigravity muscles of the neck which represent an important station for the activation of the cervical reflexes useful for maintaining the balance in stillness and in motion.

The cervico-ocular Reflex

The cervico-collic Reflex

The cervico-spinal Reflex

Since most movements of the head involve not only stimulation of vestibular receptors but also changes in length of the muscles of the neck, the interactions between the two systems is essential for maintaining head stability.

There is a dynamic additive interaction between the vestibular reflex and the cervical reflex which would underlie the normal stabilization of the head in space.

Reflex arc of cervical reflex

Afferent pathway : neck proprioceptors

Integrating centres : vestibolar nuclei

Efferent pathway : alfa motor neurons supplying the muscles

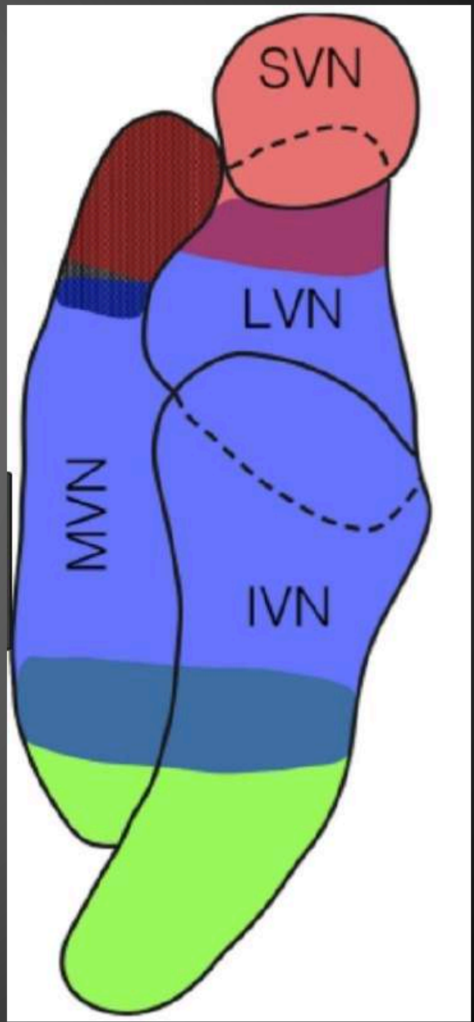
Afferent pathway : neck proprioceptors

The cervical proprioceptive afferents are provided by proprioceptors (muscle spindles) in skeletal striated muscles and tendons (Golgi tendon organ) and the fibrous capsules in joints of the posterior paravertebral region .

Integrating centres : vestibular nuclei

Medial and descending nuclei

The precise projections of the neck afferent to each vestibular nucleus are only partially known but since the neck-induced eye movements compensate for displacement in the precise plane of body motion, the vestibular nuclei must contain a discrete topographic rapresentation of cervical afferent that is similar to that of the vestibular afferents .



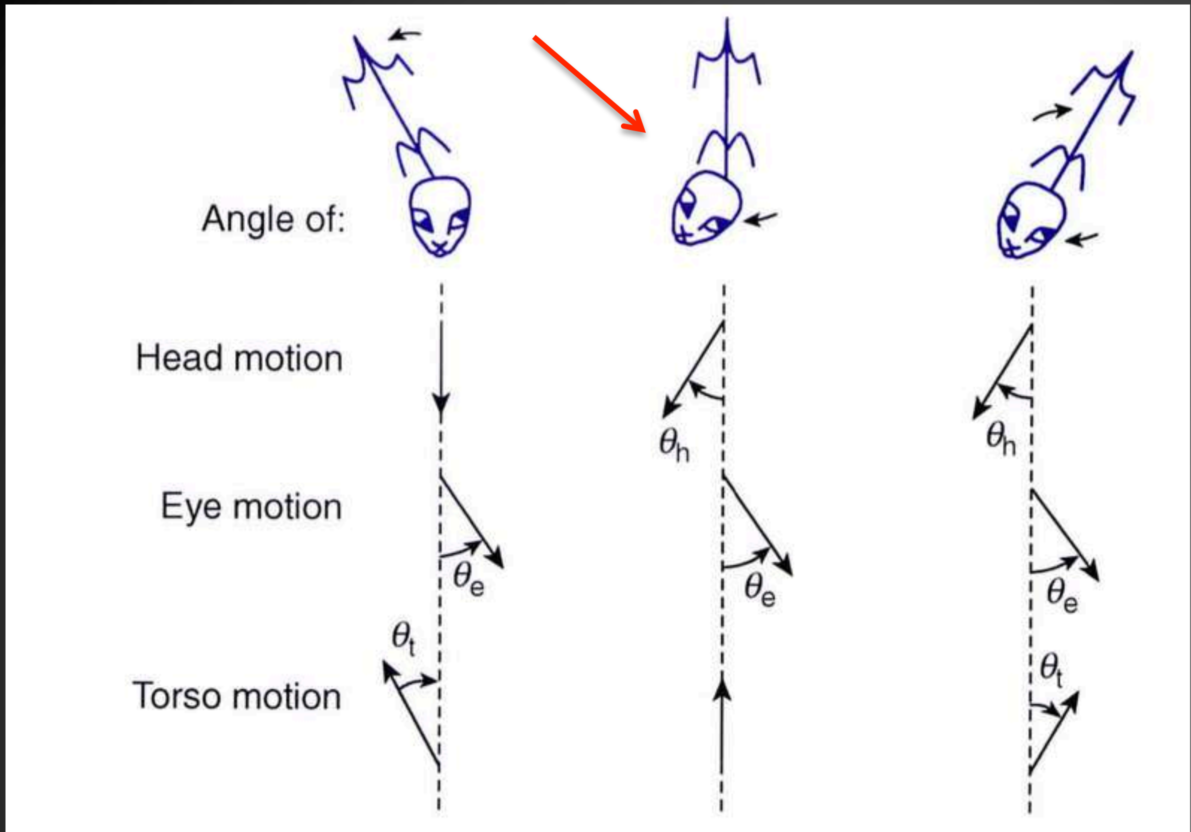
Efferent Pathway

alfa motor neurons supplying the oculomotor cervical and spinal muscles

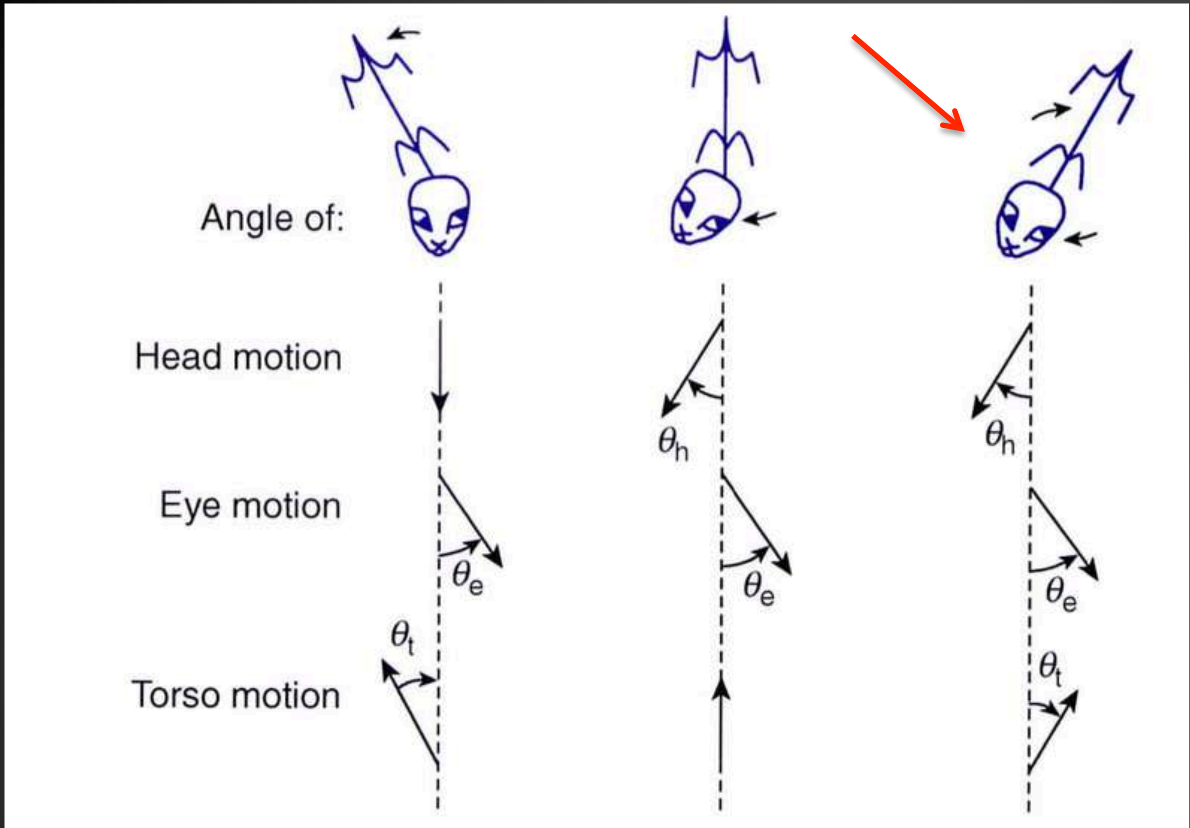
The Cervico-ocular Reflex

Ocular stability during most natural head movements results from a coordinated interaction of signals originating in vestibular, visual and neck receptors.

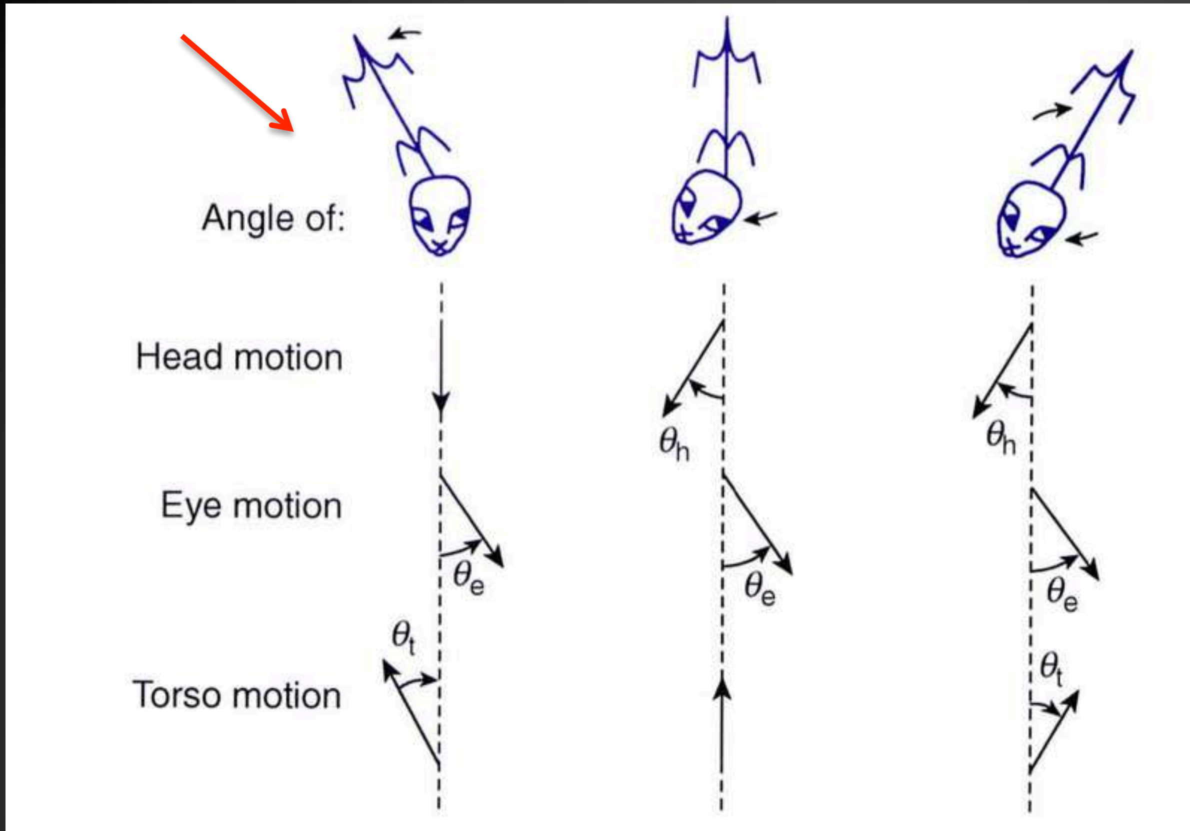
The cervico-ocular reflex consists of eye movements driven by neck proprioceptors.



When the head of a rabbit is turned to the right , the eyes turned to the left because the movement stimulates the horizontal semicircular canals and neck reflex

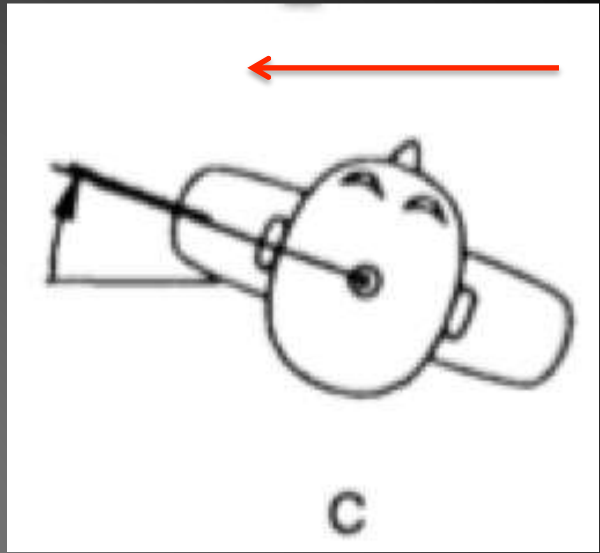


The direction of the eyes movement is the same as if the whole animal had been rotated , stimulating only the semicircular canal.

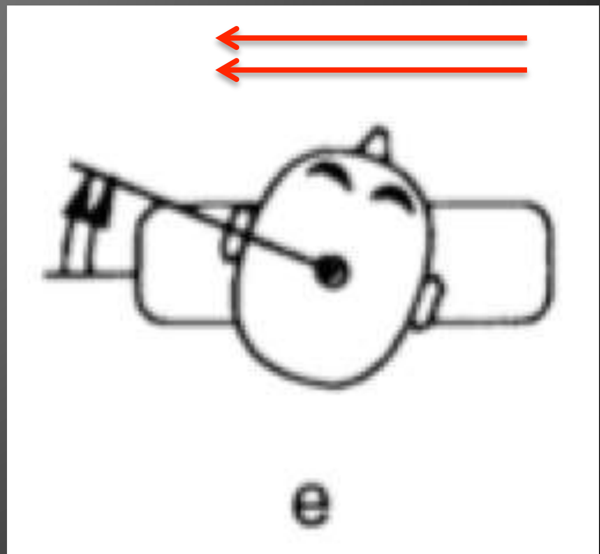


The characteristics of the neck-ocular reflex alone are evalueted by rotating the body while the head is stationary.

The angular vestibulo-ocular reflex generates slow-phase eye velocity that counter-rotates the eyes to stabilize gaze in space during angular head motion.



When the head is rotated on the body, neck joints and muscle proprioceptors are also activated through the cervico-ocular reflex .



Normally, the action of the angular vestibulo-ocular reflex is sufficient to maintain stability of gaze in space during head rotation, and the gain of the horizontal component of the angular vestibulo-ocular reflex is close to unity

If the cervico-ocular reflex complements the angular vestibulo-ocular reflex to stabilize gaze in space, then its gain should be close to zero under normal circumstances

Although the normal angular vestibulo-ocular reflex stabilizes gaze at frequencies up to 20 Hz, cervico-ocular reflex adaptation after lesions only resulted in measurable responses for stimuli below about 2–3 Hz.

The cervico-ocular reflex is therefore essentially a low-frequency system, like visual following mechanisms i.e., smooth pursuit and optokinetic responses, and the cervico-ocular reflex's normally negligible gain suggests that it is merely redundant with those systems.

However, the data indicate that the frequency range over which cervical proprioceptive inputs provide useful information about head rotation bridges the zone where neither visual following systems (which are low-pass) nor the angular vestibulo-ocular reflex (which is high-pass) can stabilize gaze alone.

As the cervico ocular reflex can supplement the vestibular ocular reflex under certain circumstances it becomes relevant when considering recovery from vestibular lesions.

Normally, the gain of the cervico-ocular reflex is very low but the is facilitated when the vestibular apparatus is injured .

After bilateral semicircular canal plugging, however, the cervico-ocular reflex velocity gain increases

The hypotheses that the cervico-ocular reflex acts to complement angular vestibulo-ocular reflex loss is also supported by a study which shows that the human cervico-ocular reflex gain increases with age as the angular vestibulo-ocular reflex gains declines, presumably due to hair cell loss.

Thus, while other mechanisms may contribute to aiding gaze compensation following vestibular loss the cervico-ocular reflex is well suited to play an important role in this gaze compensation.

Head on trunk ramp displacements in the dark evoked initial anticompensatory saccades followed by slow compensatory components, a pattern of eye movements remarkably similar to that seen during active head-eye target seeking.

Thus, in the absence of labyrinthine function, the cervico-ocular reflex appears to take on the role of the vestibulo-ocular reflex in head-eye coordination in the initiation of the anticompensatory saccade which takes the eyes in the direction of the target, and the generation of the subsequent slow compensatory eye movements.

Central pre-programming, as revealed by comparing the effect of different instructions and active versus passive neck-induced eye movements, has a profound influence on cervico-ocular reflex functioning.

Even though the velocity storage mechanism extends the a vestibulo-ocular reflex ’s frequency response down to partly overlap with that of visual following systems, gaze stabilization in this range evidently requires a combination of systems, with each acting near its limits of performance.

In addition to their role in driving a cervico-ocular reflex that is unmasked after labyrinthine injury, perhaps neck proprioceptive inputs normally play a corroborative role during activities for which no one sensory system provides a definitive signal to drive gaze stabilization.

The cervico-collic reflex

The cervicocollic reflex is a cervical reflex that stabilizes the head on the body.

Afferent sensory changes caused by changes in neck position, create opposition to that stretch by reflexive contractions of neck muscles.

The reflex was once thought to be primarily a monosynaptic one, however, long-loop influences are now being investigated.

Like the the cervico-ocular reflex, the the cervico-collic reflex may be facilitated after labyrinthine loss.

Cervico-collic reflexes have longer latencies (67.4 ms) than vestibulocollic reflexes (24.5) msec in humans, which gives normal individuals an advantage in head righting over labyrinthine defective subjects.

The cervico-spinal reflex

The cervico-spinal reflex, also known as the tonic neck reflex, is defined as changes in limb position driven by neck afferent activity.

Analogous to the cervico-ocular reflex which interacts with the vestibular-ocular reflex , the cervico-spinal reflex can supplement or interfere with the vestibular-spinal reflex.

Two pathways are thought to mediate these reflex signals, an excitatory pathway from the lateral vestibular nucleus and an inhibitory pathway from the medial part of the medullary reticular formation.

When the body is rotated with the head stable, neurons of the excitarory cervical-spinal system increase their rate of firing on the side to which the chin is pointed .

At the same time neurons thought to be in the inhibitory reticulospinal system show a reduced rate of firing .

This activity leads to exstention of the limb on the side to which the chain is pointed and flexion of the limb on the controlateral side .

Vestibular receptors influence both of these systems by modulating the firing of medullary neurons in a pattern opposite to that elicited by neck receptors.

The interaction between the effects on the body of vestibular and neck inputs tend to cancel one another when the head moves freely on the body so that posture remains stable.

Moreover, animal studies have also provided evidence for a reflex control of the head and trunk by cervical afferents, i.e., by cervico-cervical and cervico-spinal reflexes, respectively

In humans, cervico-spinal reflexes are found at birth, but come under voluntary control after some months of life

The sinusoidal neck stimulation (horizontal rotation of the trunk under the stationary head) evokes three clearly distinct turning sensations, depending on which aspect of the physical stimulus or what part of the body attention was focused on.

(i) a sensation of trunk rotation in space ('trunk in space') proportional to the actual trunk rotation,

(ii) a sensation of head rotation in space ('head in space') in the opposite direction,

(iii) a sensation of head rotation relative to the trunk which appeared to reflect simply the proprioceptive input.

The neck input appeared to combine with the vestibular induced self-motion sensation by summation, the result again depending on which part of the body the attention was directed at:

(i) With attention on 'trunk in space', the combined stimulation of the two inputs during head rotation on stationary trunk yielded the veridical sensation of trunk stationarity; this sensation was interpreted as the sum of the vestibular and the neck induced sensations, which have opposite directions and conceivably therefore cancel upon summation.

(ii) With attention on 'head in space' during the same stimulus combination, the estimates were larger than during whole body rotation (pure vestibular stimulation), as if the aforementioned neck-induced illusion of head rotation was added to the vestibular self-motion sensation.

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