Motion Interpretation

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Abstract

INTRODUCTION

The body interprets motion by way of three separate channels of input; the eyes, ears, and kinesthetic or tactile stimulation which is the perception of position and movement of parts of the body made possible by receptors in the skeletal muscles, skin, joints and tendons.

Sensory illusions may easily occur in flight especially when ground references are absent. The patient lying in the horizontal position may become disoriented due to this lack of visual perception of the ground or horizon. The ears are by far the most perceptive organ of equilibrium, due to housing the auditory as well as the vestibular organs.

Human spatial orientation and postural control require spatial integration of information from the various sense organs, along with the knowledge of self-generated motor commands and expectation or prediction of the motion pattern.[1] When these systems fail, motion sickness may occur.

REVIEW OF THE EAR

The ears encompass both, the auditory and vestibular organs. Auditory sensations effect the input transmitted to the brain by the vestibular organs. The outer ear collects sound vibrations and directs them through the auditory canal to the tympanic membrane. The vibrations are then carried to the middle ear or tympanum. The tympanum houses the osseous bones (malleus, stapes, and incus) which transmit the sound to the internal Labyrinth, or inner ear. The head of the Malleus is attached to the Incus which in turn is attached to the Stapes. As the osseus bones move against the oval window, the transmission of sound occurs.

The Labyrinth or internal ear, is made up of the vestibule, the semicircular canals, and the cochlea. The vestibule is filled with a gelatin-like serolymph material which is responsible for the transmission of sound to the Organ of Corti. Within the vestibule are the openings for the semicircular canals. These canals are filled with an endolymph fluid and are connected to a sac within the vestibule called the utricle.

EQUILIBRIUM

Two kinds of equilibrium exist. One is called static equilibrium, which refers to orientation of the body (mainly the head) relative to the ground (gravity). The second is dynamic equilibrium, which is the maintenance of the body position (mainly the head) in response to sudden movements such as rotation, acceleration, and deceleration. The receptor organs for equilibrium are the maculae of the saccule and the utricle and cristae in the semicircular ducts.[2] This orientation system is further explained in the following text.

FUNCTION OF THE INNER EAR ORGANS

When the body is at rest, the fluid within the semicircular canals of the ears is at rest. As the body moves, fluid within the canals or ducts begins to move, stimulating the interpretation of motion. The generation of signals occurs by way of the Cupula. The Cupula is a gelatin-like pendulum suspended by hair-like sensory nerve cells, located in the Ampulla, (bulge on the semicircular canal). With motion, the fluid within the semicircular canal begins to move causing the Cupula to be deflected. This motion sends signals to the brain by way of the eighth cranial nerve, ending with the interpretation of movement.

The semicircular canals are responsible for the interpretation of angular acceleration and deceleration. Within the aircraft, the semicircular canals are responsible for the sensations of roll, pitch and yaw. The flaw in this system is the lag time that occurs as the body changes the direction of motion. The fluid within the canal must come to, or very close to a complete stop before beginning movement in another direction. This lag time may send false signals to the brain, and in turn cause a misinterpretation of motion.[3]

There are two otolithic organs on either side of the head,

which help the body to interpret static equilibrium and linear acceleration. One lies in the Utricle which is a sac connected to the semicircular canal and houses the utricular macula. The other is located in the Saccule which is in proximity to the utricle.

The otolith in the utricle lies in the horizontal plane, while the otolith within the saccule lies in the vertical plan. This allows for the brain to sense linear acceleration in any direction within the normal limits of these organs.

PROPRIOCEPTIVE KINETIC SENSATIONS

This type of sensation, is the kind of sensory input that pertains to the perception of motion involving body alignment, ALONG THE TRUE VERTICAL. Turns, descents, and ascents, force the dual pulls of gravity and centrifugal force through the pilots body, and along the vertical axis of the aircraft. This may cause sensations of lightening or increasing weight of the body, and may be interpreted as flight positions. Some of the terms listed below are often used interchangeably though their meanings differ.[4]

1) THE LEANS

Leans is a condition which causes the pilot to attempt to lean his/her body in the direction of the perceived vertical plane. This condition occurs while flying without visual perception, such as in IFR conditions. The pilot and the artificial horizon do not match. The pilot may attempt to correct this feeling by leaning his body in the direction that feels correct and fly by instrument indication. In the worst case, the pilot may ignore the instruments and tilt the wings until he feels he is at true vertical. Unfortunately this method throws the aircraft off course and potentially disastrous results may occur.

2) DISORIENTATION

Loss of proper bearings, state of mental confusion as to position, location or movement.

3) VERTIGO

A hallucination of movement. A sensation of rotary motion of the external world of the individual.

4) SENSORY ILLUSION

A false or misinterpreted sensory impression; a false interpretation of a real sensory image.

5. THE CORIOLIS ILLUSION

Brought about by the combination of ear, eye, and proprioceptive disturbances. This illusion completely disturbs the perception of true vertical. This is accompanied by vertigo and a complete loss of motion perception of the true vertical.

6. ALTERNOBARIC VERTIGO

Alternobaric vertigo is caused by increased pressure in the middle ear. The specific mechanism by which alternobaric vertigo is produced is not understood. The increase in pressure due to failure of ventilation of the middle ear is gradual and usually not adequate to produce symptoms. But, in the aircraft capable of climbing at rapid rates, or with the sudden pressure caused by performing a Valsalva maneuver, the increase in pressure can be great enough to cause vestibular stimulation.

Mild eustachian tube dysfunction, such as blockage or edema secondary to upper respiratory infection, may cause the individual to use more force than normal. This increases the pressure in the middle ear, and certainly may cause enough pressure build-up to stimulate the vestibular organ.[5]

MOTION SICKNESS

Motion sickness is a condition characterized by, nausea, cold sweats, vomiting, and pallor, which is caused by exposure to perceived motion of which the person is unfamiliar with.[6] Other symptoms of motion sickness that are not always recognized are, belching and flatulence, which lead to the development of nausea. Drowsiness is another important symptom of exposure to unfamiliar motion, though not necessarily a direct symptom of motion sickness.

Motion sickness tends to be caused by the mismatch of signals to the brain. Basically, two systems are involved; (1) the visual system and (2) the vestibular system. The vestibular system is further split into the (1) angular acceleration receptor system, (2) the ampullar receptors of the semicircular canals, and (3) the linear acceleration or force environment receptors of the utricular and saccular macula or “otolith organs.”

Two main types of motion cue mismatch can be specified according to the sensory system involved. These are, (1) visual-vestibular mismatch, and (2) canal-otolith mismatch.[7]

For example, one theory states that signals stimulating the vestibular organs do not match with the visual stimulus. Another theory deals with the fact that the brain has information stored as to the effect of specific force applied to the body. If the force causes a familiar effect then all is well. If the force causes a different effect than anticipated, and for

an extended period of time, motion sickness will most likely develop.[8]

SUMMARY

The human sensory system is designed to allow the human body to interpret motion and the sensation of vertical and horizontal planes. Interpretation of flight motion tends to stimulate this receptor system in ways that must become learned responses. Experienced flight personnel tend to handle motion mismatches far better than the inexperienced occasional traveler. This is important to keep in mind when placing a patient on board the aircraft. The patient's sensory systems in many cases are impaired from trauma, illness or medication. They are on their back and are usually unable to visualize the horizon which sets the stage for motion sickness and increased stress load on the patient.

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