CHAPTER

VIII

Spatial Disorientation

BASIC SENSORY SYSTEM PHYSIOLOGY

Orientation Systems

The Human Body has an extraordinarily designed sensory system to aid in determining one's position in space and orientation to the earth. The primary orientation systems are the ***visual system***, the ***vestibular system***, and ***proprioceptive mechanisms***. We need to explore each of these systems, understand how each is designed to work and explain their importance and their place in the aviation world. Only with this knowledge will we be able to understand their effects in flight.

Visual

Vestibular

Proprioceptor

In flying, many situations an aviator may encounter can cause conflicts and sometimes illusions in the human sensory systems. The organ sensor system in question is usually working normally. However, how our brain interprets the sensory inputs may be incorrect or inconsistent with stored data. Cockpit confusion might be another name for disorientation since the information from one's senses may be in conflict with what the aircraft instrumentation indicates.

Sensory Illusions

Spatial Disorientation

Vertigo

There are three common forms of ***sensory illusions*** leading to ***spatial disorientation.*** Aviation professionals often refer to spatial disorientation as ***flight vertigo*** even though ***vertigo*** is a recognized medical condition, and the two conditions differ somewhat:

Types of Disorientation

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

Vertigo: A hallucination of movement. A sensation of rotary motion of the external world or of the individual (CAMI 1997).

Spatial Disorientation: A mental state characterized by an erroneous sense of one's position and motion relative to the plane of the earth's surface and consists of two types:

> **Type I :** Unrecognized (unaware of erroneous perception)
>
> **Type II :** Recognized (aware one has spatial disorientation but unable to dispel the false perception) (William B. Albery)

Visual System

Probably the most dominant sensory perception of spatial orientation is the eye provided there are adequate and correct reference points are available.

The eye is like a camera. Light input is processed through the anterior chamber, lens, vitreous humor, and retinal cells. The retinal cells then transmit neurological impulses to the optic stria of the brain where interpretation of the light signals is made.

Visual clues on the ground are different from those in the air. A human is used to having the ground extend to the horizon, but in the air, one may have a continuous background without a horizon. In this situation, mistakes can be made in judging the size and distance of objects. At night, the visual clue identification can be even more confusing. For example, staring at a small stationary light source on a dark night may be misinterpreted in the brain, and the brain may perceive that the light is moving. This situation is known as ***autokinesis.***

Autokinesis

Other misinterpretations may occur at night too. For example, the stars over a dark earth area may appear to be lights on the ground, and flying over the ocean may appear to be flight straight up into the sky. Such visual clues can be very compelling and very difficult to overcome. When aviators have conflicting information and perceptions, they must refer to, and depend upon, aircraft instrumentation. This may be the only life saving procedure available.

Through the years, numerous researchers have focused on the visual function, and they have come to several solid conclusions. For example, examine the following quotes*:*
"Functionally, however, vision must be considered as two separate systems, one involved with object recognition, and the other with spatial orientation" (Gillingham & Wolf).
***Focal Vision**: "Is not primarily in orienting one in the environment, but is used to acquire visual information about orientation. It is necessary for the reading of flight instruments; A very complex cognitive process — i.e., instrument flying skill — is required to convert focally acquired orientation cues into usable orientation information" (Gillingham & Wolf).*

Focal Vision

***Ambient Vision**: is primarily involved with orienting one in the environment* (see Chapter VI for a discussion of visual anatomy).

Ambient Vision

Vestibular System

Vestibular System

Inner Ear

The ***inner ear*** consists of an auditory and non-auditory portion. The auditory portion of the ear deals with the detection, transmission and interpretation of sound energy. However, the latter portion of the ear is primarily associated with ***equilibrium*** and includes the three ***semicircular canals.*** The semicircular canals are filled with a thick fluid, and each canal lies at a specific angle to each of the others.

Semicircular Canals

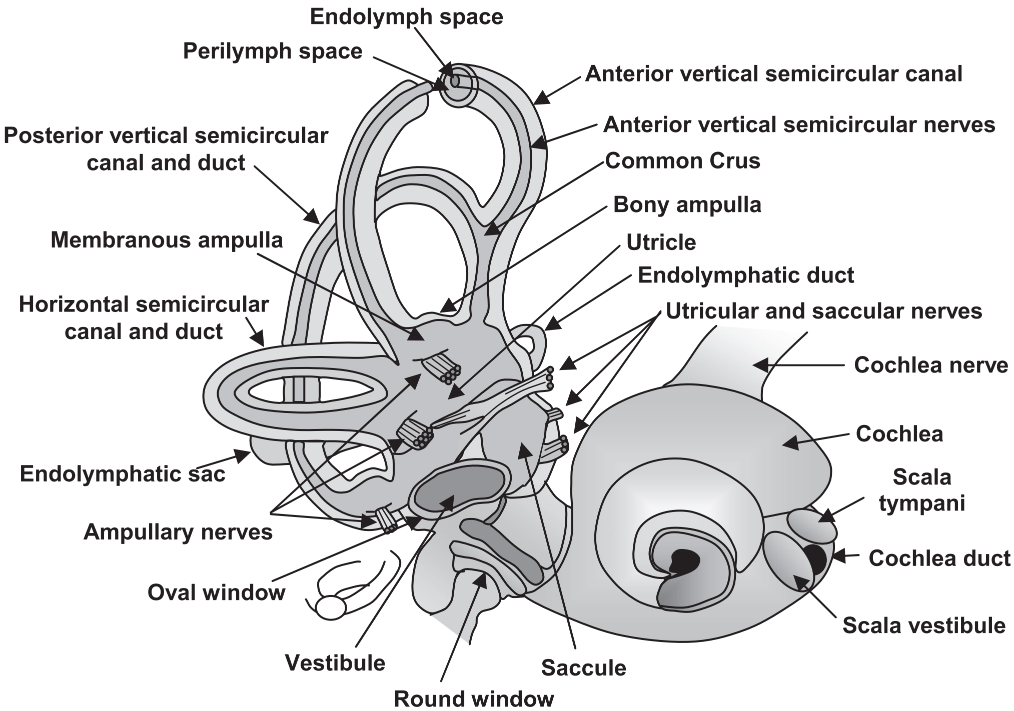

Figure 29: **Vestibular System**

Vestibular Roles

The ***role*** of the ***vestibular apparatus*** in spatial orientation is not as commanding as vision, but it is very important for three reasons:

1. The vestibular system provides the sensory input for neurological responses for the reflexes that stabilize vision when the motion of the head and body would otherwise result in blurring of the retinal image.
2. The vestibular system provides orientation information with reference to which both ***skilled*** and ***reflexive motor*** activities are automatically executed.
3. The vestibular system provides, in the absence of vision, a fairly accurate perception of motion and position, as long as the pattern of stimulation remains within certain naturally occurring bounds.

Skilled and Reflexive Motor Activity

Vestibular Anatomy

Vestibular Anatomy

One end of each semicircular canal is enlarged. In this enlarged area is a mound of sensory hair cells. Angular acceleration, or rotation, of the body along the yaw, pitch, or roll axis will move the fluid in a canal oriented in that plane. This movement displaces the sensory hairs, and an impulse is sent to the brain to be interpreted as motion about a known axis. The hairs that project into the fluid are extremely fine, light weight, and sensitive. Any acceleration greater than 2° per second will cause the hairs to be displaced, and an impulse is sent to the brain that indicates which way the hairs are bent. This is the ***sensory movement threshold***, and movements below 2° per second will not be detected. Once the brain receives the sensory inputs, it interprets the plane and relative intensity of rotation. Since the canals lie in different planes, they report movement in all three dimensions (yaw, pitch, and roll).

Sensory Movement Threshold

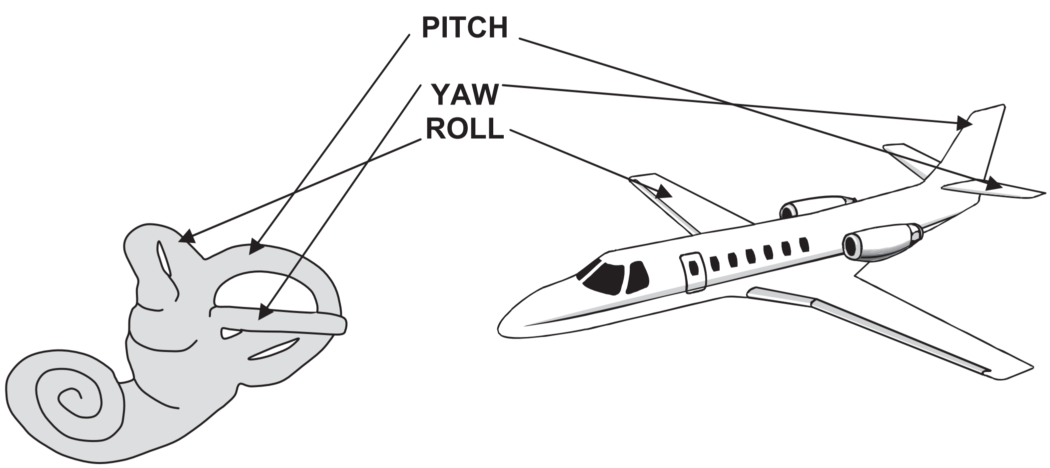

Figure 30: **The Role of the Vestibular Apparatus in Spatial Orientation**

The vestibular system works well for sudden, short turns, but, if the turn continues at a constant rate for a period of time (approximately 25 seconds), the motion of the fluid catches up to the speed of the canal walls, and the hairs are no longer bent.

In this case an aviator in a right, coordinated, smooth, constant speed turn would initially experience the feeling of a turn. However, after a period of approximately 25 seconds, the individual would feel as though the turn had stopped even though the turn is continuing. Once the turn to the right is detected, and the turn is stopped, the fluid in the canal will continue to move. In this situation, the hairs that were straight, because the fluid and the canals were moving at the same rate, would suddenly bend in the opposite direction. This would cause an opposite sensation and one would feel as though they were now turning the aircraft back to the right to compensate for the perceived left turn. As a result, an aviator would try to counteract this imaginary motion by turning back into the original turn. This would initiate a spiral or spin. Such a reaction is the physiology behind the classic ***"Graveyard Spin or Spiral"*** (CAMI 1997).

Graveyard Spiral

When the brain perceives angular motion from a canal, it will cause the eyes to react to the motion, and a condition known as ***nystagmus*** occurs. For example, when an individual is turning to the right, the eyes would sweep to the left. However, if the rotation suddenly stops, the eyes may continue their sweeping motion for up to 30 seconds. The sweeping eye movements prevent the eyes from focusing on any particular object or scene. Such a situation can be extremely dangerous especially in situations where turns are made in low visibility and high speed or in close proximity to the ground. The eye motion can make navigational aid instruments seem to sweep from side to side. This gives the individual the sensation that the "world" is spinning.

Nystagmus

Another phenomenon is the ***corollas effect.*** In this case, an aviator could be turning to a new heading and move the head down to look at an approach plate, a map or even pick up a dropped pencil. This head position could produce the sensation of a violent roll or pitch movement when, in fact, no movement took place. The result is often a violent corrective measure for a maneuver which did not occur. There have been numerous aircraft accidents associated with these sudden maneuvers.

Corollas Effect