EC CLINICAL AND EXPERIMENTAL ANATOMY
Perspective

Using Flying Examples of Spatial Disorientation to Teach Anatomy and Physiology Students the Vestibular System

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For pilots being spatially oriented would be described as correctly perceiving what is up/down in 3-dimensions and where the ground is oriented in relationship to the plane. When a pilot becomes spatially disoriented there is considered to be a disruption in the vestibular system, the visual system, and proprioceptors such that the pilot may no longer know where up/down and the ground is located in respect to his aircraft ([1], p. 117). In fact, spatially disoriented pilots often are not initially aware of their orientation error and upon recognizing that a conflict of perception exists often believe that aircraft instrumentation is in error rather than their sensory systems ([2], p. 6).

For Students in Anatomy and Physiology I classes, Neurophysiology typically comes at the end of a semester where motivation and attention are beginning to wane. The classes just before a final examination typically focus upon the special senses, visual processing, auditory system and anatomy. This may end up taking more of the lecture and lab time than desired which makes it challenging and difficult for students to grasp and understand the vestibular system and its importance. Thus, it has been my experience that using examples of spatial disorientation in aviation creates a captivating lecture. Due to the fact that aviation accidents are dramatic, students are engaged and interested to understand the vestibular system and its contributions to our spatial orientation on the ground and how it potentially works against us while flying in a 3-dimensional environment.

Vision is the most important sensory system for providing accurate spatial orientation of the four orientation systems (Figure 1). When a pilot can easily see their environment by looking outside the process of spatial orientation is effortless. Any confusing vestibular inputs are easily ignored due to visual dominance ([2], p. 6). However, when vision is degraded at times when the pilot is flying in clouds or at night, spatial orientation now comes from the less accurate vestibular or somatosensory systems. These systems do not provide reliable motion and position cues in the flight environment. Aircraft instrumentation now is required which comes at a high cognitive demand to maintain an accurate spatial orientation.

There are several ways that a pilot can experience spatial disorientation while flying. If the disorientation derives from the proprioceptive signals within our joints and muscles and/or the otolith organs (utricle and saccule) within our inner ear that typically respond to changes in gravitational force and are subjected to linear accelerations, we refer to this type of issue as Postural (Proprioceptive) Disorientation. The proprioceptors and otolith organs sense the gravitational forces while flying as "down". So, flying solely based on these input sensory pathways could be described as flying "by the seat of the pants" ([1], p. 119). In improperly executed turns of aircraft, especially while climbing with additional G-forces being applied to the body, otolith and proprioceptor signals can become confusing to the brain. If the turn results in the body being pushed sideways, as in a skid or slip, the impression of orientation is the body pushed into the seat and

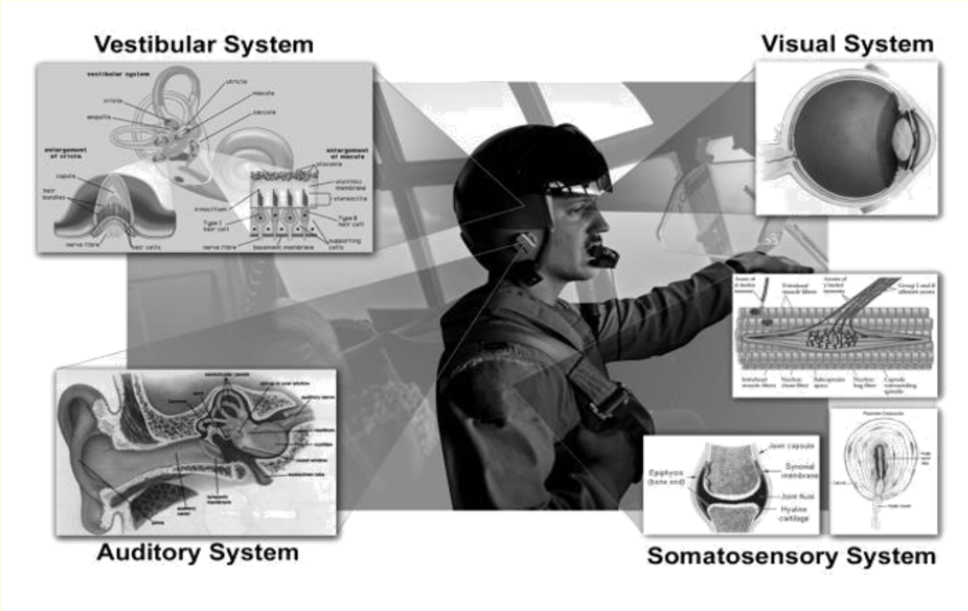

Figure 1: *Four orientation systems ([2], p. 10).*

or side areas. Without visual references this could become what is "down" and not correctly be where the ground is located in respect to the aircraft and ground. Compounding this situation, if this turn continues, vestibular inputs from semi-circular canals can start to conflict with otolith and proprioceptors "down" signal. The result is that when recovering out of the turn or potential climbing maneuver the body will feel an illusion of descending. This explanation of how we use our proprioceptors is ideal for helping students to understand that the muscles and joints do contribute to our awareness of what is considered up, down, sideways, etc. This can be mismatched with other cues leading to perceptions that are not accurate of where our bodies might be located in respect to the ground.

Vestibular disorientation is commonly recognized as feeling vertigo but unlike medical vertigo this issue is from the situation of the aircraft flying causing mismatching signals from the vestibular system with the visual and/or proprioceptors ([3], p. 59). This type of disorientation is more commonly used to describe why airsick or other motion-sickness conditions occur.

A type of vestibular illusion that known as a somatogyral illusion, a false sensation of rotation or absence of rotation ([3], p. 59) results in a misperceiving the magnitude or direction of an actual rotation. Simplifying, this type of illusion is tied to the semicircular canals to inaccurately registering a prolonged rotation. This illusion begins if there is a turn or banking movement of the aircraft that initiates fluid movement in one or more of the semi-circular canals (Figure 2). Initial accurate angular acceleration perception within the cupula-endolymph system of the semi-circular canals starts. If the turn or bank continues at the same rate for an extended time, the semi-circular canals and fluid will, through adaptive mechanisms, reach an equilibrium where signals of motion are no longer reaching conscious awareness centers in the brain. The cupula is believed to gradually return to its resting position in the absence of a changing angular acceleratory stimulus. The body will then reset into a feeling of straight-and level/up and down when the actual position is that of a turn

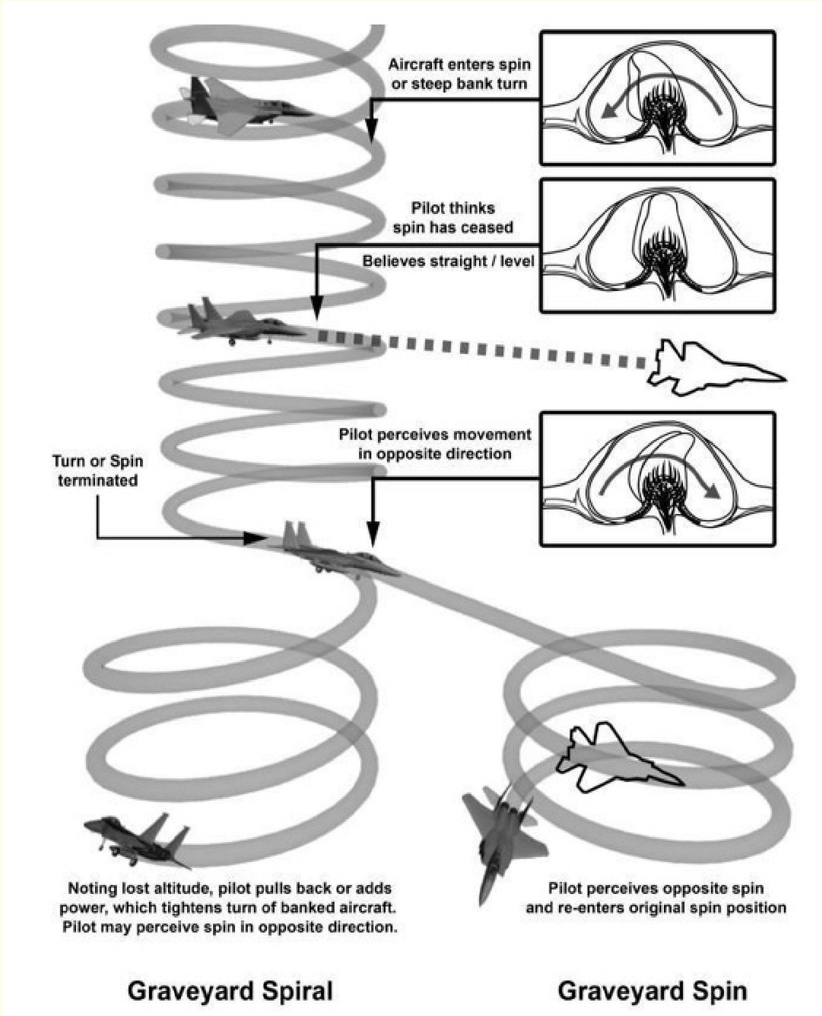

Figure 2: *Graveyard spiral/spin ([2], p. 21).*

with an angle to the ground. Pilots refer to this as a "Graveyard Spiral" ([2], p. 20-21). The illusion can continue as the turn is completed or terminated as the abruptness of the aircraft returning to attitude of straight and level is incorrectly interpreted by now reactivated semi-circular canals as turning and maneuvering in the opposite direction ([3], p. 61). Without strong visual references the pilot now feels the urge to roll-out of a turn which will actually have the effect of taking the plane from its current straight and level position back into the turn it just exited. Pilots refer to this type of illusion as the "leans" (Figure 3) ([1], p. 120). This is a great way to illustrate to students how semi-circular canals work, adapt, and can be misinformed with lack of visual cues and/or prolonged time spent in constant accelerated turns.

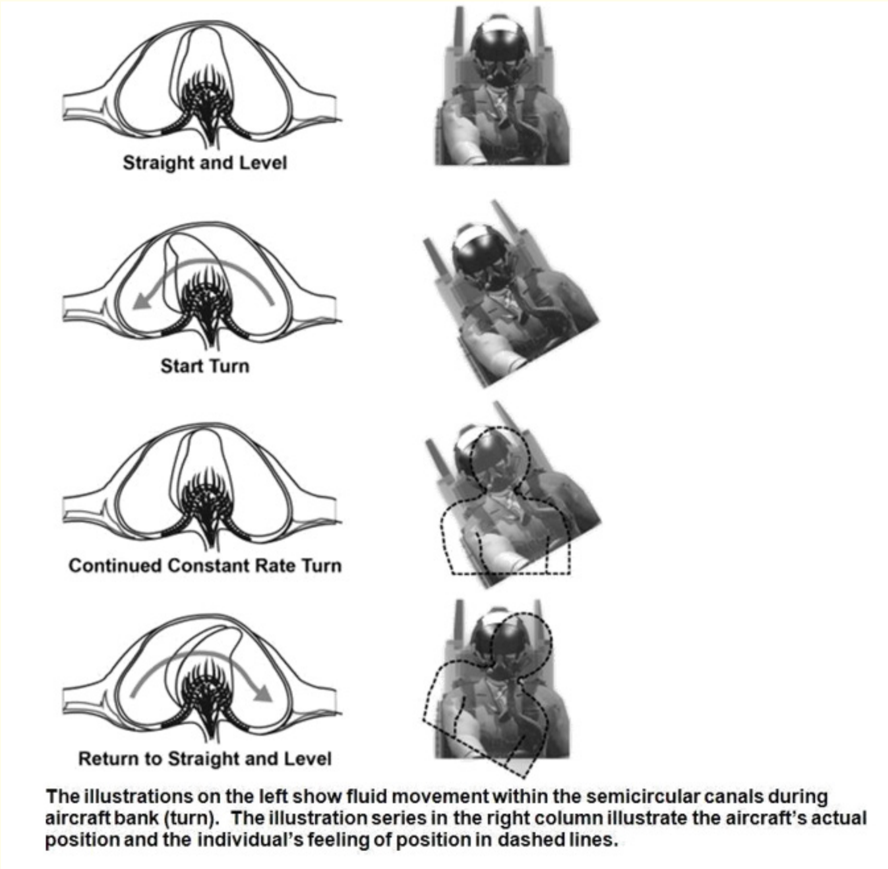

Figure 3: *Leans ([2], p. 24).*

Many students may never have the opportunity to experience these illusions first-hand but most through experiences in roller-coasters and other thrill-rides and flying experience can begin to understand some of the mismatches of perception that occurs with our four orientation systems. These feelings as well as mismatched inputs from the four orientation systems can linger and result in many potentially deadly and difficult to overcome illusions to pilots. These examples also students an appreciation to how what might be perceived as simplistic and easily manipulated for thrills and fun does have the potential for life-altering consequences within the flying environment.

Bibliography

1. Richard O Reinhart. "Basic Flight Physiology". New York: McGraw-Hill (1996): xvi.
2. Air Force Pamphlet (AFP) 11-417. Orientation in Aviation (2015).
3. Gillingham KK and Previc FH. "Spatial orientation in flight (No. AL-TR-1993-0022)". Armstrong lab brooks AFB TX (1993).

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