Understanding Spatial Disorientation and Vertigo

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EAA Chapter 162
Topics

- Why this is important
- A little aviation history...
- How the human body maintains balance and positional awareness
- Types of spatial disorientation
- Minimizing your risks
Why this is important

- Spatial disorientation a.k.a. “Aviator’s vertigo” is a persistent killer
  - At least partly responsible for 15% of GA accidents (most occur in clouds or at night)
  - 90% fatality rate

- 2004 FAA-sponsored study: average lifespan of non-instrument rated pilot who flies into clouds = 178 seconds
Not just GA pilots

- US Air Force review of 633 crashes found spatial disorientation a factor in 13% overall, and 30 percent of high-performance aircraft.
- Unlike GA accidents, most in day VFR conditions.
- Experienced pilots: 30 yrs old, 10 yrs piloting experience, 1500 hrs PIC, flown avg. 25 times in previous 3 months.
- Conclusion: no amount of expertise, training or experience immunizes against spatial disorientation.
**History**

- First ‘disturbances of equilibrium’ described by Orville Wright
- Until WWI most flights made during day and short, straight and level hops. Few risked flying at night or in clouds (and lived to tell about it).
1906: Robert Barany develops swivel chair to simulate effects of spatial disorientation
History

- 1917 - Sperry invents gyroscopic turn indicator
- 1920’s - most pilots remain convinced their instinct and perception is their best tool
- 1926 - Army Air Corps Captain William Ocker experiences Barany chair, writes “instinct is worse than useless in the clouds, and can induce deadly spirals. Having gyroscopes is not enough. Pilots must learn against all contradictory sensations the difficult discipline of an absolute belief in their instruments.”
- Army had Ocker hospitalized twice to test his sanity.
Ocker preaches necessity of instrument training, creates training aids.

“Ocker Box”
1927
History, cont’d

- 1927 - first operational gyroscopic artificial horizon
- 1929 - Jimmy Dolittle makes first flight and landing solely by reference to instruments
The instrument panel used by Doolittle on the first blind flight.
First users of IFR flight instruments claim they only work in clear weather, and go haywire in clouds. (Instruments worked perfectly).

Military leaders eventually convinced and institute spatial disorientation training by late 1920’s
Types of Spatial Disorientation

- **Type I**: Unrecognized
- **Type II**: Recognized. Pilot realizes conflict between flight instrument readings and body senses
- **Type III**: Incapacitating disorientation. Visual impairment (‘whirling vertigo’), muscle spasms, nausea, panic
Training requirements

- Primary flight training requires instrument recovery from unusual attitudes
  - Caveat: student know what will happen (Type II disorientation, but Types I and III are the killers)
- Military aviators attend refresher course in human physiology including spatial disorientation every five years
Why all this happens: Normal physiology

- Human positional awareness and balance depend upon 3 senses
  - Vision
  - Proprioception (position of head, arms, legs)
  - Vestibular system
Figure 1: The Outer, Middle, and Inner Ear

Figure 2: The Vestibular System - semicircular canals and otolith organs
Pitch: nod head ‘yes’
Yaw: shake head ‘no’
Roll: lean head left and right toward shoulders
Designed to detect acceleration, not constant velocity (either linear or angular)

A constant rate turn is perceived as no motion
a. At rest
- no angular acceleration
- no relative motion between canal and endolymph
- cupula not deflected
- no perceived angular movement

b. Acceleration
- angular clockwise acceleration
- inertia causes endolymph to lag behind
- cupula deflected right
- perceived clockwise movement

c. Constant angular motion
- endolymph moving at same speed as canal
- no relative motion between canal and endolymph
- cupula not deflected
- no perceived angular movement

d. Deceleration or stopping of motion
- canal stopped
- endolymph momentum keeps it moving clockwise
- cupula deflected left
- perceived counterclockwise movement
Pilot illusions: general categories

1. Somatogyral = spinning illusions
   - vestibular system cannot distinguish between constant velocity and rest

2. Somatogravic = acceleration illusions
   - vestibular system cannot distinguish between pitch and acceleration.
   Basis for full motion simulators.

Somato = Greek for ‘body’
Pilot illusions

1. “The Leans”
   - Somatogyral illusion after prolonged gentle turn. Returning to straight and level is interpreted as bank and turn to opposite side.
   - Pilot leans in direction of original turn to regain sense of correct vertical posture.
Pilot illusions

2. The Coriolis Illusion

- Somatogyral (i.e., spinning) illusion caused by tilting head while turning (e.g., to read map). When head moved out of plane of rotation, pilot experiences sensation of rolling (and sometimes pitching, yawing or both).
3. Graveyard Spiral

- Unaware airplane is banked but sensing nose drop or loss of altitude, pilot pulls back on yoke to regain altitude or slow rate of descent. Back pressure results in tighter turn and drop of the nose, causing further loss of altitude.

- Sequence continues until airplane stalls, breaks apart, or hits the ground.
4. Inversion Illusion

- A somatogravic (i.e., acceleration) illusion in which, after sustained climb in high performance aircraft, pilot levels aircraft causing lighter ‘seat bottom’ sensation while continuing back pressure from acceleration.

- Sensation is of aircraft continuing to increase in pitch.

- Eventually pilot perceives aircraft to be inverted.
How to minimize your risk

- Get IFR training, preferably with real world IMC (Instrument Meteorological Conditions) training
  - Special attention to transitions from VMC to IMC conditions
- When visual references lost: Die By Your Instruments
  Not by the ‘seat of your pants’
March of technology: EFIS replaces “six pack”

Caution: US Air Force human factors research on Heads Up Displays and EFIS systems suggests they can overwhelm pilot with information during unusual attitude recovery
For more information

- Smithsonian “Air & Space” Magazine
  September 2008 issue
- FAA.gov website
  - Educational materials
  - Altitude and vertigo training at 14 locations
- NASA science website: nasa.gov
- Google “spatial disorientation training”
Thanks for coming.

Keep the shiny side up, have fun and fly safely!

For more EAA programs see: www.eaa162.org

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