Aviation Medicine Seminar Series

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Aviation Medicine Seminar Series

• (1) How to Ace the Medical Exam
  December 13, 2003
  • AME training
  • How to find a Medical Examiner
  • What the exam involves
  • The 15 disqualifying conditions…
(2) **Spatial Disorientation** - January 10, 2004
- **Vestibular** based disorientation: What it is, How to deal with it
- **Vision** based disorientation: What it is, How to deal with it
(3) Common Aeromedical Problems - February 14, 2004

- Motion Sickness
- Hyperventilation
- Hypoxia
- Carbon Monoxide
- Trapped gas
- Self imposed stress
• **(4) Advanced Topics**
  March 13, 2004
  - Hypoxia/Oxygen use and abuse
  - Altitude induced decompression sickness
  - Trapped gas
  - Cabin pressurization
"Say ... What's a mountain goat doing way up here in a cloud bank?"
We possess the natural ability to maintain body orientation and posture in relation to the surrounding environment whether at rest or in motion.
• Good spatial orientation is due to effective perception and/or interpretation of your senses
  - Visual
  - Vestibular (organs of equilibrium located in the inner ear)
  - Proprioceptive
  - Auditory
INTRODUCTION

• Under certain conditions, your flight environment can create sensory conflict and illusions that make orientation difficult, and in some cases impossible to achieve.
Spatial disorientation is the loss of your orientation in relation to the earth’s surface caused by a lack of or misinterpretation of sensory cues from:

- Visual
- Vestibular
- Proprioceptive
INTRODUCTION

- **Visual** references provide the dominate sensory information to maintain spatial orientation
- Changes in acceleration are detected by the **vestibular system**
• **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 the individual

• **Spatial Disorientation:** Loss of proper bearings; state of mental confusion as to position, location or movement relative to the position of the earth.
Number of Spatial Disorientation Accidents Resulting in Fatalities

- Fatal: 90%
- Non-Fatal: 10%

Source: ASF Accident Database
Spatial Disorientation Accidents by Pilot Certificate and Weather Certificate

1990 thru 1999

- Day, No Inst. Rating
- Day, Inst. Rating
- Night, No Inst. Rating
- Night, Inst. Rating

Source: ASF Accident Database

Type of Flight

- VFR into IMC
- VFR into VFR
- IFR into IMC
Basic Physiology

- Vision
- Vestibular System
Vision
Vision

The Retina

Macula

Retina

Optic Nerve Head
An Inside View of the Eye
Visual Fields

82° AMBIENT

1-3° CENTRAL

82° AMBIENT
Visual illusions
Visual Illusions

Are the horizontal lines parallel or do they slope?
Visual Illusions

Count the black dots! :o)
Landing Illusions

- Runway width / length
- Runway slope
- Surrounding terrain
- Haze
- Smooth, solid surfaces
- Black hole
- Runway lighting
Surrounding Terrain
Runway Slope
Terrain Slope

a

b
Haze or Sloping Cloud Bank
Sensory Illusions - Visual

- False Horizon
- Confusing ground and star lights
- Autokinesis
  - At night, a stationary dim light against a dark background will appear to move if a pilot fixates on the light for 6 to 12 seconds. Can be mistaken for an approaching aircraft.
The vestibular system is located in the inner ear and is the size of a pencil eraser.

Comprised of 2 distinct structures:
- Semicircular canals (detects changes in angular acceleration)
- Otolith organs (detects changes in linear acceleration)
Vestibular System

- Otolith Organs - Linear acceleration
- Semicircular Canals - Angular acceleration
Otolith Organ: Utricle & Saccule
• The Otolith organs are in each ear at the base of the semicircular canals

• The otoliths detect changes in linear acceleration in the horizontal plane and changes in the position of the head in relation to gravitational forces
Otolith

- The structure consist of small sacs covered by hair cells
- These filaments project into an overlying gelatinous membrane tipped by tiny calcium stones
• Sensory hairs will deflect with a change in your head position
• Hairs will also deflect with sufficient linear acceleration or deceleration
During take-off with forward linear acceleration, the fluid will flow over the otolith and send a signal to the brain inducing a false sensation of over rotation.
This illusion would tell you to push forward with the controls regardless of aircraft attitude

This could cause the aircraft to nose-over...potentially ruining your day!
Semicircular Canals

- The semicircular canals are made up of three half circular interconnected tubes located at 90 degree angles from each other.

- Monitors angular acceleration and senses rotation in 3 dimensions:
  - Roll
  - Pitch
  - Yaw
Semicircular Canals

YAW

ROLL

PITCH

YAW

PITCH

ROLL

Semicircular Canals
Semicircular Canals

- Each canal is filled with a thick fluid and contains hair cells
- The hair cells moves as the fluid moves inside the canals
Vestibular Hair Cell

Kinocilium

Stereocilia

Vestibular Hair Cell
Angular Acceleration and Semicircular Canal Fluid Movement

Constant rate turn > 2 degrees/sec

Time:
- 0 sec
- > 25 sec
- Stop
Semicircular Canals

- If your head is kept still and the airplane is flying straight and level, the fluid in the canals will not move and the hair cells remain erect
  - No rotation is felt or detected
Semicircular Canals

• The somatagyral illusions concerns false sensation about the magnitude and or false perception of rotation in its actual absence
  • Graveyard spiral
  • Coriolis Illusion
  • Inversion Illusion
  • Leans
Another sensory input that plays a role in maintaining spatial orientation comes from the proprioceptors located in:

- Skin
- Tendons and Muscles
- Joints
• Proprioceptors provide information about body position and movements

• By sensing points of contact between the body parts and the surrounding environment it makes it possible for you to know your relative posture
Proprioceptors

- The problem with seat-of-the-pants flying is that in IFR conditions, they do not differentiate between straight and level and performing a 1g turn
Sensory Illusions—Vestibular

- **Otolith Organ (Linear Acceleration)**
- **Semicircular Canals (Angular Acceleration)**
  - Subthreshold acceleration
    - Leans
  - Graveyard Spiral
  - Vertigo/Coriolis
  - Inversion Illusion
    - An abrupt change from climb to straight and level can excessively stimulate the sensory organs for gravity and linear acceleration, creating the illusion of tumbling backwards.
The Leans

- The leans is the most common illusion related to stimulation of the semicircular canals
- The leans can be caused by 2 different situations while flying instruments
  - Subthreshold turns (under 2 degrees per second)
  - Rapid changes in aircraft attitude
The Leans

- Pilot’s failure to detect angular or banking motion.
- If a bank is entered slowly (<2 degrees/sec) or maintained long enough for fluid in the semicircular canals (SSC) to stabilize, and the aircraft is quickly returned to straight and level. The motion of fluid in the SSC will give the sensation the aircraft is banking in the opposite direction. The pilot will try to correct this perception by banking the aircraft into an attitude previously perceived to be straight and level.
Leans
Graveyard Spiral

Recovery from left rotational spin

Turning back into left rotational spin trying to counter right rotation sensation

Right rotation sensation after recovery
The semicircular canal is activated when you accelerate rapidly into a turn.

The fluid in the canal lags behind the accelerated canal walls and bends the hair cells.

The brain interprets the movement of the hair cells as angular movement.
If the turn continues at a constant rate for seconds or longer, the motion of the fluid catches up with the canal walls.

- The hair cells are no longer bent and the brain receives the completely false impression that turning has stopped.
Graveyard Spiral

- When you return to level flight, the fluid inside the canal will continue to move during roll-out and even for while after the turn has stopped
  - This will send a false signal to the brain indicating that you are turning in the opposite direction
• If this sensory illusion is believed, you may try to counteract it by inappropriately turning the aircraft in the original direction.

• If the turn continues and descent occurs the decent is felt by the pilot who attempts to pull back on the yolk to prevent further altitude loss. This only serves to tighten the turn and increase the decent rate. Ultimately structural damage and catastrophic failure occur prior to impact...really ruining your day!
Coriolis Illusion
The Coriolis illusion is probably the most dangerous of the vestibular illusions. This illusion involves the simultaneous stimulation of two or more canals. As associated with a sudden tilting of your head while the aircraft is turning.
This illusion produces a very incapacitating sensation that the aircraft is rolling, pitching, and yawing all at the same time.
• The best way to protect against spatial disorientation is to educate yourself about the sensory illusions and recognize your limits as a pilot.
Preventative Measures

- Take the opportunity to personally experience sensory illusions in a demonstration device
  - Barany chair
  - Gyro
  - Virtual Reality Spatial Disorientation Demonstrator
Gryo-2

• PORTABLE SPATIAL DISORIENTATION DEMONSTRATOR
Gryo-2
Preventative Measures

• By following a few precautions you can prevent or cope with these sensory illusions
  - Obtain a thorough weather briefing
  - Correct interpretation of the briefing
  - The benefit of 180 degree turn before entering IFR conditions
Preventative Measures

• If you find yourself in instrument conditions, concentrate on flying basic instruments and disregard body sensations
  • Concentrate on your instruments.
  • Remove yourself from the peripheral environment and its distractions
  • Increase instrument cross-check rate
  • Ask ATC as soon as you recognize the problem
  • Avoid head movements during turns
Preventative Measures

- Move your eyes rather than your head
- Defer non-essential task
- Relinquish control to the other pilot
- Use your auto-pilot
Summary

- **Vestibular System**
- **Semicircular Canals**
- **Graveyard Spin/Spiral**
Summary

- The Leans
- Coriolis Illusion
- Otolith Organs
Summary

- Proprioceptors
- Preventive Measures
WE ALL GET DISORIENTATION WHILE FLYING. THE REAL CONCERN IS HOW **LONG** YOU LET IT LAST.

IF YOU ARE AWARE OF THE **TIMES** AND **CONDITIONS** THAT IT’S MOST LIKELY TO OCCUR AND APPROPRIATELY INCREASE THE FREQUENCY OF YOUR REFERENCE (CROSS-CHECK) TO A VALID HORIZON, YOU’LL CONVERT **UNRECOGNIZED** TO **RECOGNIZED** DISORIENTATION.

**DAYS ARE RUINED BY** **UNRECOGNIZED DISORIENTATION** BUT NOT **OFTEN FROM RECOGNIZED DISORIENTATION**