

Blurred Lines

Recognizing the Causes of Spatial Disorientation

SABRINA WOODS

When I was a young second lieutenant in the Air Force, one of my fellow lieutenants, social buddies, and a fighter pilot, died in a horrific jet crash 30 miles outside our base. Prior to impact he had stopped communicating with his flight lead, begun making several sudden and erratic control stick inputs, and accelerated. The subsequent investigation determined that the human factors concepts of channelized attention and incapacitation due to spatial disorientation contributed significantly to the mishap. That accident was a galvanizing point in my career as an aviation safety professional.

Now, over 14 years later, a quick National Transportation Safety Board (NTSB) general aviation accident database search will show you that what felled my fellow Airman has happened to many other aviators. Approximately 243 mishaps are attributed to spatial disorientation from that time to May of last year. And that covers just the fatal ones. Almost 500 people have died — an average of about 36 pilots and passengers a year. Spatial disorientation is attributed to between 5 and 10 percent of general aviation mishaps, but from those numbers almost *90 percent* of them are fatal. That number is astronomical — and all because the lines between up and down, left and right got blurred.

Disorient Express

Our brains are amazing machines. Each neuron (we have about 100 billion) can process incoming information about 200 times a second; sending out messages at the rate of 268 mph to do what we will.

If you break that down, that is 100 billion little nerve cells each firing at around 200 times a second with over 1,000 connections between each which makes for roughly 20,000,000,000,000,000 snippets of information bouncing around your brain *every second*. This includes the billions of neurons it takes to process and form a picture of what is going on around you.

Remember the old saying that “seeing is believing?” This is particularly true for us humans. Canines rely on their keen sense of smell; bats on their exceptional hearing; but we are completely visual creatures who rely heavily on that particular sense to inform us the best. So when there is a disconnect between what we think we see and feel, and what is reality, that conflict can quickly launch us into what I call the disorient express.

This happens when we are in motion, such as at the helm of a Cessna 172, and find ourselves unable to rely on visual cues to determine true position in relation to the Earth. That situation can occur in IMC, in the early evening or night, or over water. On a picture perfect postcard flight, maintaining orientation is as simple as looking out of the cockpit. When you can see the landscape, the horizon, rising terrain and the skyline, your brain, in conjunction with your vestibular (balance) system, builds a picture of where you are in relation to those things. But take away that horizon, the ability to see the ground or even ten feet off your nose for that matter, and you lose all of that precious reassuring data. Once that

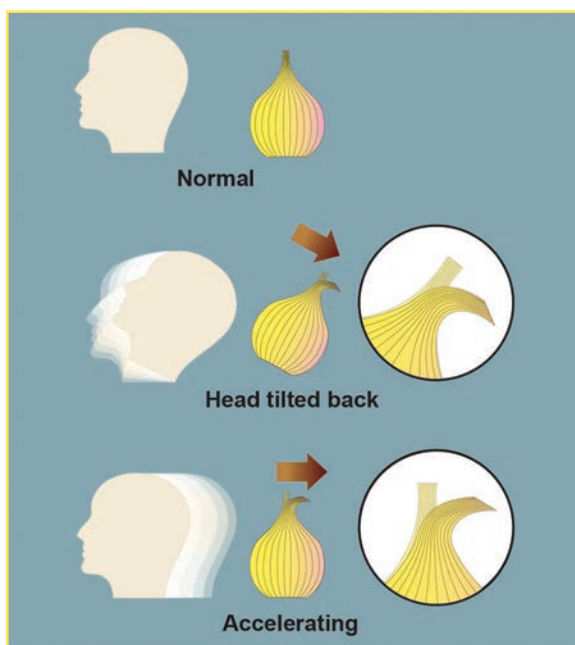
data is gone, you are far more susceptible to optical and physiological illusions.

These Are *Not* the Cues You Are Looking For

In the first category, visual deception (or misinterpretation) can happen regardless of aircraft movement or your equilibrium. Three major instances of this include the false horizon deception, the autokinetic phenomenon, and ground light misinterpretation.

The first occurs when flying between cloud layers that are not horizontal to the ground. There is no natural horizon so a pilot will have the tendency to fly in line with the clouds, which typically includes a corresponding bank. The problem is the pilot thinks he or she is flying straight and level. A few minutes in this position has a domino effect on several other perceptions and the pilot's physiology, but more on that in a bit.

The evil twin sister of this category is what is known as the "black-hole" effect. It occurs most often on approach at night or over water or anytime the horizon is not clearly visible. The pilot is unable to see anything between the intended landing surface and the aircraft, and as a result he or she can overestimate glide path or possibly believe the runway is tilted or sloped. It can lead to a disaster if this false information is what a pilot is using to make calculations for landing.



Our otolith organs manage input by using little hairs that bend back and forth in tandem with how our head is tilted.

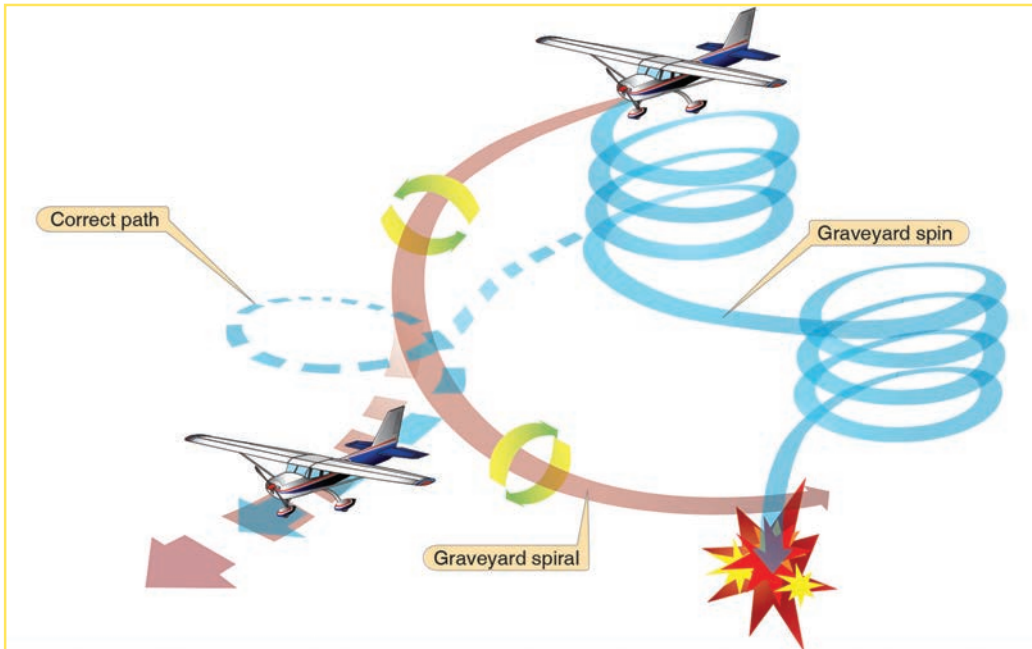
One last version of false positioning is when two aircraft are flying parallel to one another but at slightly different speeds. It can give the impression that they are slowly turning and could cause one or both of the pilots to make inputs to try and "correct" the situation. See and avoid gets a bit sinister when what you "see" is not reality and there are several mishaps in the NTSB database that can confirm this fact.

The next category is autokinesis, or the "wandering light" effect. This occurs when a pilot is fixated on a stationary light in an otherwise dark setting — usually for more than ten seconds. That light will appear to drift, giving the pilot the impression that instead of being fixed, the light is either from another aircraft — he or she will then maneuver to compensate — or that their own aircraft is making unwarranted movements. All can lead to unintended consequences. A great way to negate this effect is for the pilot to frequently shift his or her gaze in a "scanning" motion in order to avoid prolonged fixation. The study of autokinesis has also factored heavily in vertigo studies.

The last visual illusion can occur when a pilot mistakes ground light with starlight or even the light of another aircraft. The pilot will then maneuver in order to try to reposition the lights above them — in the instance of starlight — or to try to "catch up" with them, such as when flying in formation. This last category is believed to have factored heavily in my aforementioned fighter jet crash. The investigators theorized that in an attempt to rejoin with his flight lead, the pilot fixated on a reflection of light from standing water on the ground and followed it, believing it to be his wingman. The rest resulted in complete disorientation and incapacitation, which brings me to the physiological side of the discussion.

You Are Here (?)

Your vestibular system is responsible for managing your sense of balance and spatial orientation so that you move fluidly. Its base of operations is housed in your inner ear and the whole complex system is no bigger than a large pea. It is made up of two major components: the semicircular canals that detect changes in rotational acceleration, and the otolith organs which detect linear (straight) acceleration. While an essential system to be sure, it is not the most sophisticated when it comes to interpreting minor inputs or adjusting for inputs that come too close together in succession. This is compounded when in flight where it is even more difficult to get a good "read" because sensory stimuli vary in direction, frequency, and intensity.



The graveyard spin is by far the most disorienting and unrecoverable of the major physiological illusions.

Because the vestibular system is slow to adjust and works within a specific range — input typically has to be more than two degrees per second — it creates a mismatch in what you are interpreting and what is actually so. This is that disconnect I mentioned earlier. Some more common vestibular induced illusions are what we call the “leans,” the graveyard spiral, a somatogavic illusion, and the Coriolis Effect.

The “leans” is the most common form of spatial disorientation in aviation. It can result when a banked attitude is entered too slowly to set in motion the fluid in your semicircular tubes (they perceive rotation, remember?) or when a gradual turn is abruptly aborted causing the fluid in your ear to “overcorrect” and giving you the sensation that you are now banking the opposite direction when in fact you are straight and level. This is disorienting and may cause you to provide even more inputs in an attempt to “right” the situation, thus leading to loss of control.

The appropriately named graveyard spiral is by far, the most disorienting and unrecoverable of the major physiological illusions. Also known as the suicide spiral, or death spiral, it occurs when a pilot intentionally (or unintentionally) enters a tight turn. As established in the “leans,” any bank entered too slowly to be registered by the vestibular system may result in the wing dropping, and the pilot doesn’t realize that the plane begins to turn. Because the instruments show decreasing altitude, the pilot may

pull back on the stick and add power, thus inducing a tighter turn. As the plane spirals downward and its descent accelerates, the pilot still senses the descent but not the turn.

The word “somatogavic” is derived from *somato*: meaning “of the body;” and *gavic*: meaning “pertaining to gravitational forces.” This difficult sounding spatial disorientation category is actually quite simple: it occurs when there is an abrupt change in aircraft acceleration. This can happen in any direction: linear, rotational, or vertical.

Our otolith organs manage the input by using little hairs that bend backwards and forwards in tandem with how our head is tilted. If we accelerate (or decelerate) too rapidly in any given plane, even if our head is stationary, the gravitational forces still affect these little hairs and cause them to bend in the direction of the force. In other words, even if your head is secured in one place, if your airplane rapidly increases speed, the otolith organs adjust accordingly, bending backward if you are accelerating and forward if you are decelerating. This also occurs if you should sharply bank or roll from one side to another. The hairs bend side to side.

Conflict is introduced because that system takes a little time to readjust. That means that even if the acceleration/deceleration, bank, or roll is terminated, the sensation that you are still moving in that direction can persist. Another issue is that the sudden movement can induce a strong over-tilt sensation. This is exacerbated when there are no visual

cues to help you reconcile what you are feeling, such as in IMC. This could cause you to either climb or lower the nose in an attempt to (incorrectly) compensate for what you are feeling. An all-too-frequent result is loss of control.

Last is the Coriolis Effect. Abrupt movements of the head while turning send the fluid in your ears into a mini whirlpool, which creates the sensation that you are tumbling head over heels. This is most likely to occur when you look down at something (e.g., chart, navigational aid, etc.) while in a turn and then suddenly back up out the cockpit. This vertigo-inducing maneuver produces the unbearable sensation that the aircraft is rolling, pitching, and yawing all at the same time. It can quickly disorient you and cause you to lose control of the aircraft.

PSA

VFR into IMC is the number one cause of spatial disorientation and the failure to rely on instruments — whether through lack of training/certification or through selective omission — is the number one reason a pilot is unable to recover once affected.

One more thing about all of those NTSB reports: I cannot tell you exactly how many of the narratives started with “The non-instrument rated pilot ...,” but there were many. These three little words are significant and they become the basis for my public service announcement. If you haven’t already done so, take the next step. Invest in the training and get your instrument rating. File IFR when you fly, even if you are planning a VFR route. The benefits, to include updated weather forecasts, and air traffic and radar coverage, are substantial.

Next, maintain proficiency in using your instruments and learn to trust them. Almost all of these physiological and visual deceptions can be avoided by constantly comparing what you see and feel with what is represented on your gauges. When in doubt, go with the gauges.

Last, you’ve spent so much time learning your wonderful aircraft, maybe now is the time to learn a

little more about yourself. You are on the right track by reading this magazine and keeping informed about safety concerns in aviation, but you can take it a step further by participating in a physiological assessment of your own. You can do this by experiencing spatial disorientation illusions in an aviation physiology course. A little experience in one of their brain-scrambling devices can help you understand how these conditions can affect you specifically, and that knowledge can be invaluable. The FAA’s Civil Aerospace Medical Institute hosts a one-day course that does all of this, as well as provides survival and hypoxia tips. To find out more go to www.faa.gov/pilots/training/airman_education/ and click on Aerospace Physiology Training.

On June 12, 2001, I lost a peer and comrade in arms. He was highly trained, skilled, and in top physical condition, and yet he succumbed to the factors that encouraged spatial disorientation. His loss was the catalyst for my wanting to learn more and more about how we humans think, work, and interface with our machines. It is my honor to pass what I learn on to you. Together, through continued training and education we can keep our National Airspace System the safest in the world.

And to my departed brother I say; “Push it up, Chongo!” 

Sabrina Woods is an associate editor for FAA Safety Briefing. She spent 12 years as an aircraft maintenance officer and an aviation mishap investigator in the Air Force.

Learn More

FAA Safety Brochure: Spatial Disorientation

<http://go.usa.gov/3AFFA>

FAA Safety Brochure: Aviation Safety Courses

<http://go.usa.gov/3AFMB>

AOPA Safety Advisor

http://flighttraining.aopa.org/students/maneuvers/topics/SA17_Spatial_Disorientation.pdf



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