Spacial disorientation

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Soaring

SOME TIME DURING my sophomore year in college a little incident happened — I won't bore you with the details — that made a deep lesson crystal clear:

I could be knowledgeable, rational, intelligent, and foresighted in my thinking; confident in my conclusions for all the right reasons — and be dead wrong.

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The deep lesson was that it was when we are justifiably most confident that being wrong is most dangerous, as it's then that error takes us by surprise.

This lesson applies to aircraft accidents, and stall/spin accidents in particular. Your senses and mine can and will convince us of a reality that is the opposite of what exists. In fact, what we know about the brain's physiology, about human perception and the powerful reflexes that govern balance and orientation, leads to the conclusion that some accidents are *not* preventable. Some combinations of maneuvers can in some circumstances irrecoverably disable our organ systems (irrecoverable, that is, within the time needed to save the aircraft and ourselves).

However my goal in this essay is not to convince you that your flying ability is likely to disintegrate fatally, unexpectedly and soon, but to show you that subtle illusions can slightly alter what you are actually doing with an aircraft versus what you think you are doing with it.

In the 1930s there was controversy in aviation about whether a good pilot could maintain coordinated flight within clouds. Most pilots "knew" that a skilled pilot could enter cloud, use ball, needle, airspeed, and compass to stay within safe limits and maintain control, and come out the other side intact. Those who didn't lacked ability — those who did had the right stuff. Similarly, in reading accounts of soaring accidents during the ten years I've been involved in the sport, and listening to instructors, there is a clear message that stall/spin accidents should not happen to experienced, attentive pilots. I don't recall any article in which perceptual illusion was claimed to be a major contributing cause of an accident. But an understanding of our balance organ — the vestibular system — leads to the conclusion that sometimes this must happen.

A recent soaring accident reviewed in *Soaring* (December 1998 and February 1999) is an example of one in which a major cause could have been a "vestibular" illusion. I'll show how this could happen to me, or you, or any skilled pilot under the right circumstances.

In the 1930s, good pilots did sometimes fall out of the clouds, and they still do with annoying frequency. In the '90s, even solidly experienced, skilled soaring pilots still get into the occasional stall/spin accident. It's clear from the reports of those who survive that they were usually paying pretty close attention to business, and that the loss of control was a big surprise. There was a fellow in the 1930s, just after Jimmy Dolittle in 1929 demonstrated the feasibility of blind flight, who began to appreciate that these confident, skilled, attentive pilots sometimes were not handling their airplanes quite as they thought they were. He worked hard to persuade the military aviation community that better instruments were necessary for safe cloud flight. But so confident were these skilled, experienced pilots, so sure were they that the crashes were due to lack of skill, inattentiveness, or insufficient discipline, that they felt he was raising a minor issue at best, and some simply thought he was crazy. In fact, he was put through a psychiatric evaluation at one point.

But accidents kept happening and, eventually, enough reasonable people discovered the awful reality — of being confidently wrong in cloud — that even the military was persuaded that this was true, and Col. Joseph Duckworth was permitted to establish an instrument training school. His techniques of attitude flying are still the foundation of such instruction.

In the following decades a great deal of research has been done to discover how we pilots can be confident and wrong. Kent Gillingham and Fred Previc have written about these illusions succinctly in "Spatial Orientation in Flight", chapter 11 of Roy DeHart's *Fundamentals of Aerospace Medicine*, 2nd edition. Their terse account takes up ninety pages. There are many, many ways in which our senses can create an erroneous reality for us, illusions which can maim and kill. Only our awareness of these and our fear of them sneaking up on us can make us cautious about believing we're the hotshot, athletic critters our egos want us to believe we are.

All this accumulated experience and research has paid off. Instrument pilots hear a lot about "spatial disorientation" in their training, and for the very good reason that this phenomenon can break airplanes and kill their occupants. An error that this excellent training may permit is the belief that these phenomena are only important in instrument flight, or in other situations of reduced visibility. True, they are a continual problem in instrument conditions, but vestibular illusions are present full time and fail to delude us only because of redundant, overlapping, corrective information from other sense organs — especially vision — and continually cause control handling errors, most of which are slight, unnoticed and quickly corrected.

A common misconception shared by pilots is that "spatial disorientation" means that the pilot feels confusion about the orientation of the airplane. The important

point about these illusions is that the pilot feels no confusion, no uncertainty about the fact that his or her "seat of the pants" feeling is wrong; the confusion only occurs after the pilot becomes aware of conflicting sensory input. Any instrument-rated pilot has surely had moments of vertigo — troublesome or frightening confusion about which way is up or whether the airplane is turning, but this confusion is normally the beginning of spatial re-orientation. Rarely, the confusion can't be resolved and a crash occurs.

The important lesson about spatial disorientation is that it's most dangerous when there are few cues that it exists, and when the pilot is confident of which way is up and which way the airplane is pointed. Research on spatial senses in man has revealed several interesting ways in which a pilot can be completely confident yet significantly off, sometimes completely backwards, sometimes off just enough to land short. To say this another way, with spatial disorientation, confusion or the sense of disorientation only occurs when the pilot becomes aware of conflicting sensory information. Until this occurs, the pilot believes that the stimulus being attended to is valid and reliable, and feels confident.

When the pilot has conflicting non-illusory sensations, this does not guarantee that re-orientation will occur. Clear and unambiguous visual perception is highest in the hierarchy; but this is not always quickly available to the pilot. It is only when some piece of discordant sensory input is attended to that awareness of disorientation can occur. A proxy for discordant sensory input is the intellectual awareness that the pilot is in a situation in which illusion is likely. This is the basis for and the rationale for physiological training.

Let's re-analyze the key points of the glider accident reported in *Soaring*. Let me be clear that I am not writing this because I have special knowledge of the accident, or to say that all the other analysis is wrong. Accidents are generally due to a combination of factors, as this one may have been. This particular accident is worth analyzing because it illustrates my point that an experienced and skilled pilot could have a "normal" experience that initiated a surprising and painful accident, and because a similar situation could bite you if you are not aware it is possible. First, from the December article:

The pilot of the glider was circling above a ridge searching for lift, and circling beneath a 1-34 in hopes of sharing a thermal. The key sentence is, *"... not finding any lift under the 1-34, he craned his head back to look directly overhead to centre beneath the other glider."* We will assume that he was making left turns, although the direction is immaterial except to make the analysis clear.

Physiologically, the important point is that this pilot, a competent fellow who knows how to fly, was in an established banked turn at the moment he needed to look vertically. This would require him to rotate his head back and turn it to the right. If he had been in the turn for as much as a minute (probable, given that this was thermaling flight), his vestibular system (semicircular canals and otolith organ) would have stabilized. When a pilot in a stable turn rotates his head to the outside and tips it back, an inevitable, strong sensation is created of banking more steeply and diving.

When this pilot looked directly overhead, most of his visual references to the cockpit and to the ground were dramatically changed and diminished. Technically, this is "degradation of visual referents," which is well known to predispose to motion illusions. To maintain a sense of remaining in a stable turn, he would have to pull back the stick and bank toward level. He would have been strongly motivated to obey the seat of his pants by his sense that he was close to the ridge. Whether he was 300 feet as he reported, or 955 feet as the GPS said isn't material; the point is that if the ridge "felt" close, the pilot would have been more motivated to maintain a coordinated-feeling flight than if he had been comfortably high. (Because of dithering, GPS altitude readings are characteristically off ±300 feet or more. The GPS reading does not meaningfully contradict the earlier report.)

This heightened attention to coordinated flight when we feel low is, I judge, an important factor in stall/spin accidents. Up high, we tend to let the airplane wander a little when we get distracted, without worrying; down low, we ride herd on it more closely. Ironically, taking more care may actually raise the risk of an incident. How? Simply this, if we respond quickly to correct the airplane, we will respond to our senses before checking to see if the motion we feel is illusory. Therefore, down low, when we are trying to be more precise, we are more likely to respond to the illusion and be fooled.

It's also important to realize that these illusions feel right. *There is no confusion.* The December article goes on to say, "At that point, he indicated that he might have become disoriented, causing the stick to be pulled back excessively, and for the ship to skid. It immediately went into a spin." Well, this is the language of someone who was surprised, who is looking back at the fact that a spin happened and is trying to understand the cause. It does not say, "The pilot said he became confused." It is the pilot acknowledging that, because the spin happened, the aircraft could not have been in the safe attitude he felt it to be in and which he was trying to maintain.

In this particular case the pilot was flying a glider which doesn't give much warning of a stall, so he had no opportunity to perceive the illusion that injured him. I hope you do not think, just because this pilot crashed, that he was incompetent, poorly trained, careless, negligent, or indulging in deliberately risky thrill-seeking. In fact, the articles cite several signs of careful planning for possible disaster and awareness of its possibility. The fact is that someone as careful and skilled as you could, while intending to be extremely careful, experience exactly the same type of motion illusion and crash, with the same humiliation, the same raised eyebrows, the same adverse presumptions about pilot judgement and skill. Now let's turn to the second key fact of this accident. The GPS data from the flight was analyzed. The pilot says, "The data shows that I was flying straight and level for approximately 1 minute after making the 180° turn in which I craned my head back to look up at the 1-34 .... So, the spin developed from some other reason rather than my distraction with the 1-34."

The GPS data proves that the pilot did respond "appropriately" to his vestibular sense, and did level out and straighten while looking up at the 1-34; the physiological point is that during this time he would have *felt* as

though he was continuing in a stable turn. If he had *not* had this illusion, his vestibular system would not be functioning as designed. Got that, guys and gals? The illusion is inevitable. It occurs because the system is working. It occurs because one's cross-checks (visual and tactile referents) are diminished. Everything feels right. Suddenly something happens that shouldn't — a stall — and the pilot must quickly re-orient. What about recognition and recovery?

As the airplane quits flying, the pilot's vestibular system is continuing to function normally, sending wrong information to his cerebral cortex about the glider's motion. This interferes with his ability to recognize and recover from the spin. From the pilot's point of view, something happens suddenly and unexpectedly. He turns back to look out the front window, and the message that this head movement sends to his cortex is that the glider has pitched up and banked to the right. Meanwhile, the actual movement of the glider has been to pitch his head down, and to turn it to the right or further to the left, depending on the spin rotation — or perhaps the glider is not rotating; his head movement has only given him the sensation of a spin and the glider is actually in a deep stall. In this case, it will feel right to apply opposite rudder, which will actually cause a spin.

Ignoring the vestibular illusions, let's realize that this is not a training session, where we expect a spin for learning purposes. All the pilot knows at first is that the controls are slack and the world is cockeyed. Has he had a mid-air with an unseen glider? Has the elevator disconnected? It will take time to sort this out, time that may not be available, given the alacrity and enthusiasm with which gravity operates. Now holding in mind that such a situation developed because of motion illusions, what will overcome these illusions? Only a stable visual reference. This may not appear until the spin is fully developed, nose down and dropping. Prior to this, the sense of rotation may be either exaggerated or wrong, and the pilot has wrong (inadequate) clues that this perception is wrong.

Let's add one more inconvenient fact into this mix: sudden rotations may induce *nystagmus*, a condition in which the eyes are stimulated to flick rapidly back and forth — what you saw when your friend got off the playground merry-go-round after you and his other playmates had spun it long and hard. If nystagmus develops, the eyes aren't able to fixate on anything, instruments or ground, and control movements will be guided by vestibular sensations — which will be correct only if the highly skilled, experienced, athletic pilot is very lucky.

Therefore, there are circumstances in which a stall/spin might be inevitable, and some instances in which the superb pilot is genuinely incapacitated from recognizing the pitch of the aircraft and its direction of rotation during those few seconds in which recovery is aerodynamically possible, and these circumstances can arise in the *normal* conduct of glider flight: thermaling "low" over ridges or during the approach to landing.

Back to our story. The pilot says, "So, the spin developed from some other reason rather than my distraction with the 1-34." Correct. Is it clear to you what the "other reason" may have been? His sentence contains a common misconception: that it is "distraction" that is the problem. It is not. We must attend to many cues throughout flight, especially in traffic. Every "cue" distracts from every other.

The problem is head movement in turns. Head movement in a turn always creates a vestibular illusion. This illusion is usually overridden by redundant correct sensations, chiefly visual ones. Unfortunately, to avoid all risk of this illusion means not turning the head: not checking for traffic, not checking ground reference points when landing, not visually checking for flap, spoiler, and gear handle positions, not checking charts. That would not be safe either. These illusions then, although they exist in good visual conditions, are seldom a problem because of redundant overlapping perception. They are a special risk for glider pilots because they do occur, they are usually unrecognized, and when they aren't, the pilot is simply mystified about how such a skilled, alert pilot as myself got into trouble.

How can we avoid such accidents? Be aware of the particular situations in which they can occur. When in a turn, tipping your head up or down, or turning it from side to side as we all must do to check traffic and ground references, or to look at charts, notes, and instruments creates false sensations of the glider tipping or turning that can unexpectedly cause uncoordinated flight or slow airspeed. When your head is "on a swivel" discipline yourself to keep the controls stable and do not fly by "feel". Re-establish visual reference with the horizon and the yaw string before "correcting" bank or pitch. ❖