BY DR. DANIEL L. JOHNSON

The Numb Brain

(All prior columns are at: tinyurl.com/drdanscolumns)

Rock-a-bye pilots,
When the lift tops
and the wind blows,
the glider will rock.
When the wing breaks,
the glider will fall.
Down will come glider,
pilot, and all.

A springtime cold front had passed, bringing unstable air and the promise of excellent soaring and high bases. Saturday had been a nice, long day, with a 300 km triangle, and Dan launched under an overdeveloped sky with guarded optimism.

The cu were flat and high, but widespread, 80-90% overcast. Thermals were not booming, so getting near cloudbase took almost half an hour. Dan was amazed to find that the modest lift was everywhere, and another big triangle felt like an easy way to spend the afternoon. The bases were 6,000 AGL, the winds aloft light, the savanna below mottled beautifully with the soft and variegated greens of early spring. The glider's heater was AWOL, but he was prepared. He headed west on his first leg.

As he flew along, Dan began to be aware of being profoundly sleepy. It was a great effort to stay awake, and a few times he was startled to blink and find the glider in a gentle descending left turn (*microsleep*). This was annoying and worrisome.

Soon the task began to seem uninteresting and not worth the effort to complete it. Was he still tired from yesterday's long task? Had his sleep been poor that night? He looked at his flight computer. He was so high that from 40 miles out, final glide back home was easily done. He turned, coasted back home, and put the ship in the box.

What happened here? Have you ever felt sleepy in your own glider? Why does this happen? Why is this important?

Motion-Induced Fatigue

When we want our babies to sleep, we rock them, or take them for a ride in the car. Sleep seems to be a natural response to gentle motion for both humans and other mammals.

Motion-induced drowsiness was first reviewed by Graybiel & Knepton, in 1976, who called it "the sopite syndrome" after the Latin *sopire*, "to lay to rest, to put to sleep." When I first discovered it, after that short spring flight, there wasn't much literature.

But scientists and safety experts have, during the past decade, become keenly aware of this phenomenon, which has caused difficulties for truck, bus, and train drivers, airplane pilots, and seamen. In drivers, it's called "motion-induced drowsiness." In seamen, it's called "motion-induced fatigue" and referred to as MIF. (A friend, when asked about her cruise, said, "Boy, I really slept well!")

If we reflect, we have surely felt this while driving. We can easily stay awake at work or at home past our normal bedtime, but sleepiness can be disabling during these hours while driving.

Most news reports blame inadequate sleep, as if the victim must have been living recklessly. Yet though inadequate sleep makes this more likely, the treatment is to stop micro-accelerations. Lying in bed will do this, as long as the bed isn't in a moving vehicle or boat. If we stop at a cafe and have coffee, we are applying two therapies, quietude and caffeine. Both help.

Only in 2003 did a scientific paper, by Christopher Brill and Richard Gilson, suggest that motion-induced drowsiness might be an important factor in driving accidents. Before that, attention was all on inadequate rest periods, partying, and shift work.

A difficulty with airplanes is that we can't pull over and step out. When the Northwest pilots overflew their destination by 45 minutes a few years ago, they anticipated derision, dismay, and disrespect from confessing that they'd fallen asleep, so claimed that they'd been distracted by a debate about company documents on their laptop computers. This of course led to a cockpit ban on laptops and other useful personal tools.

Motion-Induced Error

While sleep may be catastrophic in airplanes, vehicles, or even boats, it's equally important that the sopite syndrome includes loss of motivation, decreased interest, and increased errors. For example, warfighters traveling through rough terrain in an armored carrier for four hours had a 5% increased error rate as well as fatigue, sleepiness, or nausea.

Panagiotis Matsangas led a study specifically of the effect of sopite syndrome on multitasking performance which showed a 32% decrease in memory (recall) and 15% decrease of arithmetic ability (think: subtract headings) and a 9% decrease in overall performance. Retention of learned material was not worse.

Their results showed that cognitive multitasking performance declines even when motion sickness and soporific symptoms are mild, and that impairment begins some time *after* the symptoms.

Trucks, Trains, Planes, Ships ... *and Buildings!*

Tall buildings are an issue here. New methods of building construction involve stronger and lighter materials, leading to taller buildings that are less heavy, with less damping and lower resonant frequencies. During storms, these wind-excited tall buildings move very perceptibly, exciting the occupants emotionally.

For 40 years, it's been known that all types of motion sickness occur in swaying tall buildings. This includes, obviously, drowsiness and perhaps increased error rates – yet the blame is laid on bad decaf, poor sleep, partying, and the flu.

Air traffic controllers in towers can detect accelerations of 0.6 milliG (1/1000th

gravity). At 5 mG, about half of people in tall buildings report movement, and above 10 mG motion sickness begins to occur. Typically, there's a sequence: increased errors, then fatigue or demotivation, then nausea.

In buildings, there's more than seat-of-the-pants sensations, of course. The first thing is noise from the building itself, somewhat alarming, perhaps. Then hanging fixtures sway, or co-workers may cry out.

Motion "Sickness"

The most reliable way to quickly provoke significant motion sickness (i.e., vomiting) is to induce accelerations that affect both the semicircular canals and the otolith apparatus. A rotating, wobbling chair in darkness does the job in under a minute, and if that isn't thrilling enough, quickly reverse and rotate the other way. Think "Tilt-A-Whirl."

Severe motion sickness may include cold sweating, giddiness (from slowed heart rate and decreased blood pressure, the "vasovagal response"), nausea, and vomiting. As you may have discovered personally, the nausea or loss of appetite may linger for hours to days.

Milder adverse physical responses to motion include salivation, jerking eye movements (*nystagmus*), lassitude, impaired coordination, non-communicativeness, and drowsiness. These affect motivation and accuracy, which are important for safe flying, and hinder learning in the student.

Graybiel and Knepton particularly noted a disinclination to be active, physically or mentally, or to participate in group activities, and mild depression. These don't enhance performance. It's important to remember, as Matsangas, *et al.*, showed, that "cognitive multitasking performance declines even when motion sickness and soporific symptoms are mild."

Visually-Induced Motion Sickness

As you've probably experienced at some point, it's possible to get seasick without moving. This is "visually-induced motion sickness" and appears to be related to *vection* (the illusion of motion). This is the giddiness we feel as the helicopter crosses the ridge in the wide-screen movie, the movement we feel when the car next to ours creeps forward at the stop light or the subway on the next track pulls out of the station.

Visually-induced motion sickness can be induced without vection. For example, this can be reliably produced by a pattern of alternating black-and-white horizontal stripes rotating around a stationary observer seated in front of a curved projection screen, with the stripes in the peripheral visual field rotating oppositely to the stripes in the central visual field. The observer doesn't experience motion, but usually feels nausea.

Other, more complex visual rotations can do this. This is called [video-] "gaming sickness," [flight-]"simulator sickness," or "cybersickness" depending on the circumstance. Abnormal eye movements and spatial disorientation occur with these, though not in motion sickness. I wonder whether tight thermaling might have this effect, due to the visual rotation, over and above the g-effect of thermal turbulence.

Visually-induced motion sickness does involve drowsiness and fatigue just as vestibular-induced motion sickness. Surely glider-sickness involves both visual and vestibular factors – after all, we spend a lot of time pirouetting in bumpy air.

These factors may act somewhat differently. The physiology of motion sickness is complex, involving several areas of the brainstem and inputs from several sources. I get sleepy but not nauseated with extended thermaling, and I vomit quite alertly after doing too many wingovers.

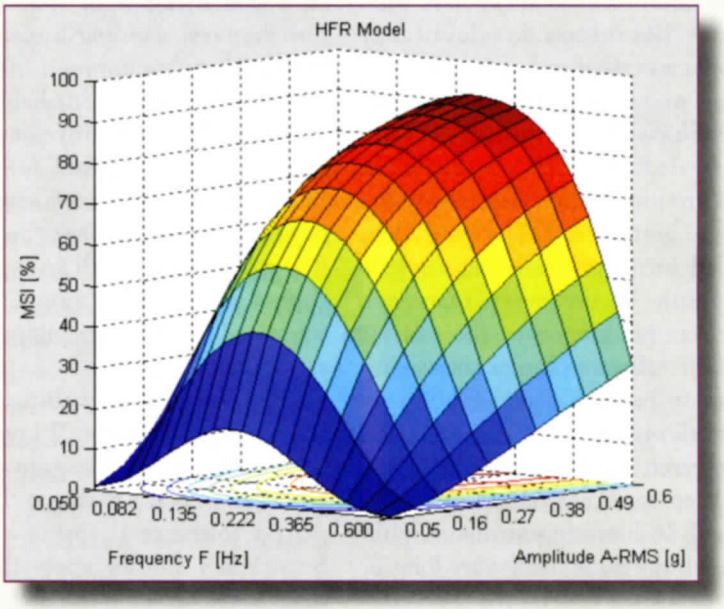
Vestibular-induced motion sickness

In this regard, vestibular stimulation of just the right sort causes much more severe distress than visual stimulation. Slow oscillations involving modest accelerations are the worst.

The illustration (above) is a model of human sensitivity to seasickness. It displays the percentage of people who will vomit after two hours of exposure to various up-down G forces alternating across a range of rates (frequencies) of change.

As shown in the illustration, 90% of people will have vomited by 2 hours of

Model of human sensitivity to seasickness



HFR = Human Frequency Response
MSI = Motion Sickness Index (% who vomit)
A-RMS [g] = Root-mean-square amplitude as a fraction of G, the force of gravity.
F = Frequency in Hz (cycles per second).
Since these are all < 1 cycle per second, take the reciprocal to find seconds per cycle. In this diagram:

Hz	Seconds
0.050	20
0.082	12
0.135	7.4
0.222	4.5
0.365	2.7
0.600	1.7

+/- half-G accelerations in 6-second cycles, but fewer than 25% will if the cycles are more than 10 seconds or less than 1.5 seconds. But 6-second cycles of only 0.25G will cause 66% to vomit.

I recall my father relating a Navy voyage as Ship's Doctor during WWII – he was puzzled that their weather yacht pounded around in the Aleutians without anyone getting sick, and yet, when they sailed into the gentle slow swells of the South Pacific every man jack of them was hanging over the rail (at which point Admiral Nimitz showed up in his comfy battleship and asked why they were all out of uniform).

This research has been done with the idea of keeping Navy sailors alert and functioning. It does suggest that dolphin flying should be done using very long or very short cycles.

Preventing Motion-Induced Cognitive Dumbness

1 -Habituation and tolerance

(Fly often.)

It's very clear that people habituate to motion. Seasickness has been very carefully studied. This is special because people are trapped aboard ships for days, while we can jump right out of the airplane in the worst case. In ships, by 2.5 days, nearly everyone has achieved tolerance in the sense that they're not vomiting.

Habituation may be faster if the victim can take a break, which is essentially what we do because flying is done only for hours at most. A break can be as simple as flying straight and level for a few minutes, avoiding turns, turbulence, and dolphin flying.

It may be possible to habituate without flying. A competitive aerobatic pilot wrote that he prepared for the season by standing on his head several times a day for a couple of weeks before his first flight. It's a study with an N of 1 and no control, but provokes thought. When I've suggested this to other pilots they always say, "I'll fly."

Regardless, we will habituate if we fly a lot. It's a good excuse. "I know the lawn needs mowing, but I've got to get my habituation in while there are thermals."

And tolerance is lost if we don't fly. Seasickness studies show that about a third is lost after a week, so flying at least every weekend is obligatory, eh?

2 - Artificial or real horizon

Having boat passengers look at an artificial horizon that moves properly with the boat decreases seasickness significantly in formal studies. This justifies the old advice to keep your eyes on the sea, not in the boat.

This is one more reason to keep our head "out of the cockpit" when maneuvering, and to use an artificial horizon instrument during poor visibility. It's interesting to think that motion sickness during cloud soaring might be less with an AI.

3 - Manage other fatigue causes

There are many, many things that cause a sense of fatigue. Of course they add up. Making sure we're getting adequate rest, managing social stress, well hydrated, avoiding hypoxia, managing jet lag or shift work, and so on, are all important things.

Drowsiness is not the same as fatigue. Lack of sleep, or poor-quality sleep, are the main causes. In the Obese Culture (2/3s of Americans are obese), obstructive sleep apnea is prevalent. This causes poor cognitive performance as well as CG worries. But it's not limited to the obese.

A lean, healthy married couple each said to me, confidentially, "I don't have sleep apnea, but I wish you'd talk to [my spouse] about getting a sleep study." I broke confidentiality by telling them when we were all together about this mutual worry. Now they sleep with twin CPAP machines and, laughing, tell me how very much better they feel – and, most important, about how much clearer are their minds.

Every pilot in whom I've found sleep apnea tells me later that what keeps them using CPAP, and taking it on trips, is the mental clarity it brings. They feel smarter and make fewer errors.

In fact, the making of inadvertent errors is one of the most important clues to something being awry physically.

4 - Drugs

My career is devoted to the prescrib-

ing of drugs. It's what "physician" means. Believe me, they are wonderfully useful. But every drug has undesired as well as desired effects, and the first requirement of any drug is that it be *tolerable*, in relation to the need.

Unfortunately for pilots, a primary side effect of medications effective for motion sickness is *drowsiness*. This is a problem for the pilot, the driver, the boat captain, and the train engineer, as we were hoping to *avoid* drowsiness, not merely nausea and vomiting.

5 - Caffeine

Caffeine is beneficial in treating *motion sickness* only when combined with other drugs such as antinauseants. But it's the ideal medication for sopite syndrome, for it's the safest, most effective stimulant on the market, and available in some extremely delicious forms. I have found that taking caffeine decreases my own sopite symptoms greatly, preventing the overpowering sleep urges.

Coffee in the hydration bottle works well, except that the extra fluid load adds to the excretory challenge on a long flight. Espresso is an obvious answer if you like it.

My own solution is caffeinated Shot-Bloks. Each has 33 calories of sugar and 50 mg of caffeine, plus electrolytes. I chew one Blok 20 or 30 minutes before flight, and one every 20-40 minutes during flight. A whole sleeve is 250 mg of caffeine, which creates a buzz.

6 - Triptans

The triptans are the most effective medications for acute migraine, which is often associated with nausea. A couple of studies found that taking 10 mg of rizatriptan (Maxalt™) before exposure to a seasickness-inducing situation decreased symptoms in about half the people who took it.

There are a couple of drawbacks here. One is that 10 mg costs about $80. The second is that triptans cause mild sedation, which is not going to be helpful for the sopite syndrome and motion-induced Numb-Brain Syndrome.

7 - Meclizine (Antivert) and other antihistamines

As a physician, I have not been very impressed with the efficacy of meclizine for dizziness, and it does cause drowsiness and impair cognition. I have read that cetirizine (Zyrtec, a less sedating, newer antihistamine) with caffeine is reasonably effective.

Cinnarizine (Stugeron) is an antihistamine not marketed in the US that is reported to be effective if administered at a 50mg oral dose before a rough voyage. Although cinnarizine is not licensed by the FDA in the United States, several studies report cinnarizine as the most effective antihistamine with the fewest side effects.

It's my judgment that no one should use diphenhydramine (Benadryl) or other "first-generation" antihistamines because they increase driver errors as badly as alcohol, for much longer (due to their long pharmacologic half-lives), and cause cognitive errors even in those who do not feel sedated. I see no reason to keep them on the market (well, except that they're a lucrative business).

8 - Scopolamine

Scopolamine (Transderm Scop) is used for the prevention of motion sickness and for its treatment.

Expected adverse effects are dry mouth, nose & throat, *drowsiness*, loss of visual focus, and sensitivity to bright light. Other normal adverse effects may include palpitations, urinary retention, bloating, constipation, headache, and confusion (or delirium).

Scopolamine, prescribed as a transdermal patch, should be administered at least 30 minutes prior to exposure to motion stimuli.

I do not prescribe this for anyone, unless they are purely a passenger with no decision-making responsibilities, and insist on having it.

9 - Ondansetron

Ondansetron is highly effective for nausea and vomiting, but it has been shown to be unhelpful in preventing seasickness in highly susceptible persons even in high doses.

10 - Fragrance

I did find an article, "Visually-induced motion sickness can be alleviated by pleasant odors." In this study, half the subjects didn't notice the rose fragrance used, and those who did notice it had less visually-induced motion sickness (watching a vertigo-producing video).

Does this mean that you should wear rose-scented cologne when flying your glider? Why not? Let us know whether it helps.

11 – Excitement

John Sullivan points out that finding ways to make the flight exciting and interesting is a great antidote to drowsiness. Flying with another glider, even making the flight a friendly competition, creating interesting navigation challenges, getting excited about the scenery, all help deflect drowsiness.

After all, motion-induced drowsiness is not all-powerful. It's simply one influence among many on alertness and fatigue. We do have the power to make decisions that reduce the net effect of influences to be fatigued or sleepy, or that make the flight more interesting or exciting.

Selected References

Graybiel, A. and Knepton, J. (1976), "Sopite syndrome: a sometimes sole manifestation of motion sickness", Aviat. Space Envir. Md., 47(8), 873-882. http://www.ncbi.nlm.nih.gov/pubmed/949309

The classic reference.

The illustration on sea-sickness is from Panagiotis Matsangas, http://tinyurl.com/Seasickness-index