SOARING Rx

BY DR. DANIEL L. JOHNSON

Jet Lag and Night Shifts Make Us Bad Pilots

Early to bed and early to rise,
makes a man healthy, wealthy and wise.

Gerry had been signed off to solo last week, and was excited to have an afternoon to practice. It had been a long week at work – one of the other nurses had a family emergency and Gerry had had to pull a night shift three times in a row. She was glad not to feel sleepy this morning, but she'd really needed that first cup of coffee. Twice. Espresso.

She finished the checklist and gave the wing runner a thumbs-up. He lifted the wing, she waggled her rudder. She bumped across the grass, focusing carefully on all the tiny details that would someday become unconscious. There was just *so* much to keep track of!

The grass of runway 36 suddenly faded away, the bumping stopped. Stick pressure forward, keep the wings level, upwind rudder to keep her nose behind the towplane's tail. Two-hundred feet. She looked around the pattern, listened to the vario chirp, settled down. Her thoughts drifted for a moment – this was *such* fun; *so* satisfying.

All her life she'd wanted to do this, and finally, this summer, her ducks were lined up She'd get her license before fall; she just knew she could do it.

She glanced at the altimeter. The long hand swept across the top, across the zero. "Yikes!" she said, "Two thousand feet!" She felt foolish at letting her mind wander. The towplane had simply flown straight north. She wondered how far away the airport was. So as she turned right after releasing, she completed a 180 to check the distance.

"Yikes!" again. She suddenly realized that she'd pulled off early. She had misread the altimeter. It was only 1000 feet, and here she was about a zillion miles north of the airport and low to boot! She imagined pattern entry, realized with a shock that she was already at pattern altitude, and went back to the checklist: **E** for Emergency. She felt criminal violating all the rules about altitude and pattern entry, but decided just to go straight in. She'd never done a downwind landing, and remembered being told that the rudder quits working before the glider stops.

She put the humiliation aside and kept the airspeed needle on minimum sink. She pushed the button and said nervously, "Cornpone gliderport, November Seven Two Idiot, Final one-eight." A Freudian slip. As she flew closer, she could see that she'd just make it, and relaxed: the airport wasn't going down on the canopy, but it wasn't going up, either.

She landed, rolled out, stopped, and opened the canopy. She unbuckled, climbed out, and her instructor zoomed up in the golf cart. "Great job!" he said. "Did you have a rope break? What a bad time for it!"

The compliment made her more ashamed. She wanted to deserve it; thought about lying. It was just too humiliating. Maybe she was losing her faculties. Maybe she shouldn't take up soaring, after all. "No," she said, "I pulled the release prematurely."

"You handled it great," said her instructor. "No one flies perfectly! The important thing is to handle our mistakes safely!"

What happened?

Gerry's brain wasn't normally sharp because the night shifts had messed with her circadian rhythm (Latin: *circa*, about + *dies*, day). We would call this "shift work sleep disorder" – this and "jet lag" are simply different names for different paths to the same thing: poor mental function from out-of-sync biological rhythms. The brain malfunction occurs even if we're not particularly sleepy. Gerry wasn't old or senile! But she *was* impaired – more than she realized.

Misaligned circadian rhythms have caused diplomatic gaffes, airplane and auto accidents, untimely marriages, medical catastrophe, and embarrassment like Gerry's. They chronically afflict international pilots, traveling businesspersons, medical workers, and industrial workers. Oh, and did I mention mothers of infants?

Jet lag is caused, basically, by trying to sleep and work at the wrong time within the circadian cycle, and by being exposed to light and dark occurring at times that badly reset our internal clock.

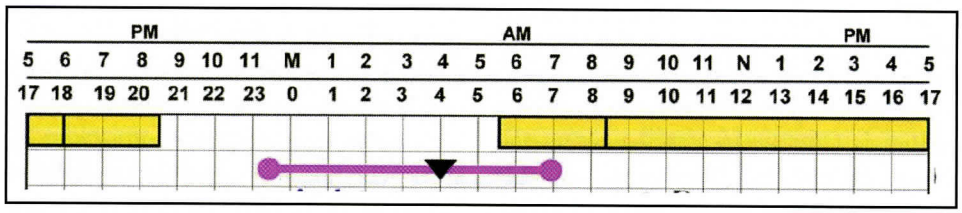
Jargon Alert

What do we mean by "biological rhythms"? Nearly every living creature has a natural biological rhymicity that affects metabolic and hormone function. The heartbeat is merely the fastest cycle we notice. We humans have a 90-minute gonadal-hormone cycle, a daily sleep cycle; women have a monthly fertility cycle, we have puberty and senescence, and so on. Circadian rhythms (daily rhythms) include the sleep cycle, blood pressure variation, alertness, immune activity, the morning cortisol peak, and others. These rhythms are controlled by a master circadian clock in the brain. This is a built-in rhythm that is synchronized or *entrained*, daily, by dark and light, evening and morning.

The performance problem is that our best brain function depends on this synchrony. Our times to perform must be aligned with the optimal phase of the circadian cycle. When these get out of whack, we may be sleepy during the day, wakeful at night, intellectually dull, cranky, or lazy. Our gut may not work right. We feel bad.

Circadian misalignment is most commonly caused by travel across time zones (*jet lag*) and shift work (*shift-work sleep disorder*). Our need to work and to be alert has been moved to the time when we customarily sleep. This often entails lack

Figure 1



of sleep, but sleep deprivation is different and more easily fixed. (With sleep.)

Sleep Deprivation

Please note: lack of sleep leads to fatigue and sleepiness, but does not cause jet lag. (We really need a more accurate catchy phrase than "jet lag," yet *circadian misalignment* lacks panache, though I like it as part of my fun-jargon campaign.)

What to Do?

There are really two challenges: one is to know how to shift our circadian rhythms when crossing time zones or changing work shifts.

The other is to *maintain* our circadian rhythms in case our work or sleep schedule gets jacked around for any reason.

The basic rhythm

Figure 1 portrays a typical 7-hour sleep period in a 24-hour day.

- The yellow bars depict sunlight hours, including seasonal variability at beginning and end.
- The magenta bar represents a normal sleep period.
- The black triangle is the key point: **Tmin**, the point at which our body temperature is at its minimum, the point at which we are sleepiest, the fulcrum around which our hormonal tides ebb and flow. This occurs about 3 hours before awakening for folks who sleep 8 or more hours daily, about 2 hours if we sleep 7 hours or less.

The key to avoiding circadian misalignment is to keep this triangle within our sleep period.

The problem, of course, is that work or travel may require that we be awake then, and sleep at other times. This causes Personal Circadian Agony (jet lag).

How to Manage the Tmin

Our Tmin shifts in response to **light** and **dark**. It only shifts a little – about an hour or two, at most, each day. If you follow the recommendations here, you can conveniently assume that it moves one hour each day.

If we mismanage this, it might shift in the wrong direction, or even get confused. The shift can be modified slightly by physical and social activity, and meals. (Perhaps this is why we read to children quietly, and sing, at bedtime, and try not to excite them or feed them sugar.)

When traveling east, we want Tmin to occur earlier each day (advance it) until it matches the time zone we've gone to. We can best do this by exposing our vision to medium to high intensity light 2 hours earlier than usual the first day (beginning at Tmin), for up to 3 hours, and an hour earlier each successive day. It helps if we are in the dark (or very dim light) for the 3 hours before this point.

How bright should be the light?

Well, sunlight works. Sunlight is from about 20,000 to 100,000 lux. Daylight without direct sun is 10-25,000 lux. Lights for Seasonal Affective Disorder are 5 to 10,000 lux and are bright enough.

"Medium to high intensity" means 1,230-10,000 lux, as has been found effective in research. Shorter light exposures are effective with brighter lights: one study showed that using 10,000 lux for the first 15 minutes of each hour was enough; another showed that 1,230 lux continuously for 3 hours is enough.

Indoors by a bright window is usually not bright enough; a north-facing window is about 2000 lux. Office lighting is typically at or below 500 lux, and is not bright enough; TV studio lighting is about 1,000 lux, and is *probably* not bright enough.

Light and dark both affect our clock

It's important that we have this dim-light / sun-light period whether we are sleeping or not. We need to have it at the proper time, in the right sequence. We can use very dim indoor light or very dark wraparound sunglasses. We need to use daylight (outdoors or medium to high intensity indoor lighting (15 minutes each hour may be enough).

When traveling *west*, we want to *delay* Tmin, so that it occurs *later*. Interestingly, this is done most effectively by experiencing medium to high intensity lighting in the middle of our normal sleep period, for about 3 hours, before Tmin, or in 15-minute sessions each hour for 4 hours. This can be done easily if we've crossed the Pacific, but is a little harder in a busy hospital ward.

Going west, delaying Tmin, we also want to have *dim* light for 3 hours *after* Tmin. This means dimmed computer screens, dim room light, and very dark sunglasses if we must be outdoors.

Again, it helps to have this sun-light / dim-light period whether or not we are allowed to sleep, oriented to our presumed Tmin time, as it delays an hour a day.

Melatonin can Help

Melatonin is the body's *lights-out* hormone. It is secreted in response to the master circadian clock (in the *supra-chiasmic nucleus*, you'll be glad to know), beginning about 2-3 hours before our usual bedtime, if we're in fairly dim light. It is an important influence in synchronizing our circadian rhythms. Bright light *suppresses* melatonin.

We can protect our own melatonin production by making the lights very dim before bedtime (turning down our computer screens, closing the blinds, turning room lights to sleazy-tavern level). We should do this shortly before bedtime if we want to preserve our normal Tmin.

We can also do this by taking melatonin capsules. Take 0.5 mg to 1.0 mg, as low doses work better than higher doses, and 3 mg or more impairs intellectual performance even when it doesn't cause drowsiness. (Thus pilots should not use the higher doses, and should not use it for several hours before flying.) Melatonin is available over the counter and unregulated in the U.S. If the manufacturer is following voluntary purity standards, the bottle will say, "NF" or "national formulary" somewhere.

Figure 2 shows where daylight and melatonin can be used to advance (travel east) or delay (travel west) Tmin: (The blue line shows the normal melatonin level.)

Combinations

Going west, medicinal melatonin actually helps very little. Timed bright light, supplemented by timed dim light, is ideal. Sleeping pills can be useful to avoid sleep deprivation.

How to Do it Wrong

Suppose that you are going seven time zones east, and that your Tmin occurs at 4:00 am local time. You want to keep Tmin within your longest sleep period, and you'd like Tmin to creep back toward 10:00 pm at-home time ("phase advance" = "occur earlier in clock time").

The problem is that 4:00 am at-home time is 11:00 am destination-time. If you inspect Figure 2, it shows that bright light before 11:00 am destination-time will "phase-delay" Tmin an hour or more. So being out in the sun on the way to your important company meeting will delay Tmin to noon or 1:00 pm destination-time, and tomorrow you'll be brain-dead just when you need to be reading the fine print on those contracts. And this will continue day after day until Tmin finally creeps around the clock past destination-bedtime.

How to prevent this? Try to advance Tmin by two or three hours before you leave by going to bed and getting up earlier, with bright light on arising; and wear really dark wraparound sunglasses or stay indoors before Tmin at your destination, with really bright light or a stroll in the sunlight after Tmin. An after-lunch walk is good for digestion, anyway.

Sleeping Pills

First, for pilots, the FAA does not approve the use, before or during duty, of any prescription sleeping pills or nonprescription sleep aids such as diphenhydramine (a long-acting antihistamine that causes drowsiness, ubiquitously available in over-the-counter sleep aids). Certain prescription sleeping pills may be used once or twice a week when off duty.

Second, sleeping pills do improve sleep, but *do not* improve daytime intellectual function during jet lag. Dr. Charmane Eastman points out, "Even if you've had a lot of previous sleep you will still feel sleepy around your Tmin, because we've been programmed to be sleepy at night by millions of years of evolution."

Individual Differences

Everyone's exact rhythmicity is unique. Most people delay their internal clock a few minutes every day if deprived of light cues; a few advance it a few minutes earlier. Older people, as with nearly everything else, adjust less well and are affected more.

I found a survey saying that about half of international travelers deny being bothered by jet lag. Well, more power to them! But I think they're "in denial," as the pop psychologists say.

A Plan for Travel

The keys:

1: You can start the adaptation process long before you leave, depending on your work schedule and social responsibilities.

2: You don't have to sleep the same clock times while away as at home – decide before leave just how much shift is best, and then plan to shift about an hour a day toward that goal.

3: The most important part of the strategy is the light/dark timing, and the timing of melatonin if you use it. You may as well plan on sleeping on the airplane if you can; if you can schedule the flight so that your Tmin that day is during the flight and can sleep then, so much the better.

4: Take your extra-dark glasses and use them when you have to be in daylight or other bright light until you're fully adjusted.

Preserving our Circadian Rhythms

Sometimes life is chaotic for a while. Then we need to try to figure when we're most likely to be able to sleep every day, plus or minus an hour, and then move Tmin to that spot and be sleeping then whenever we can.

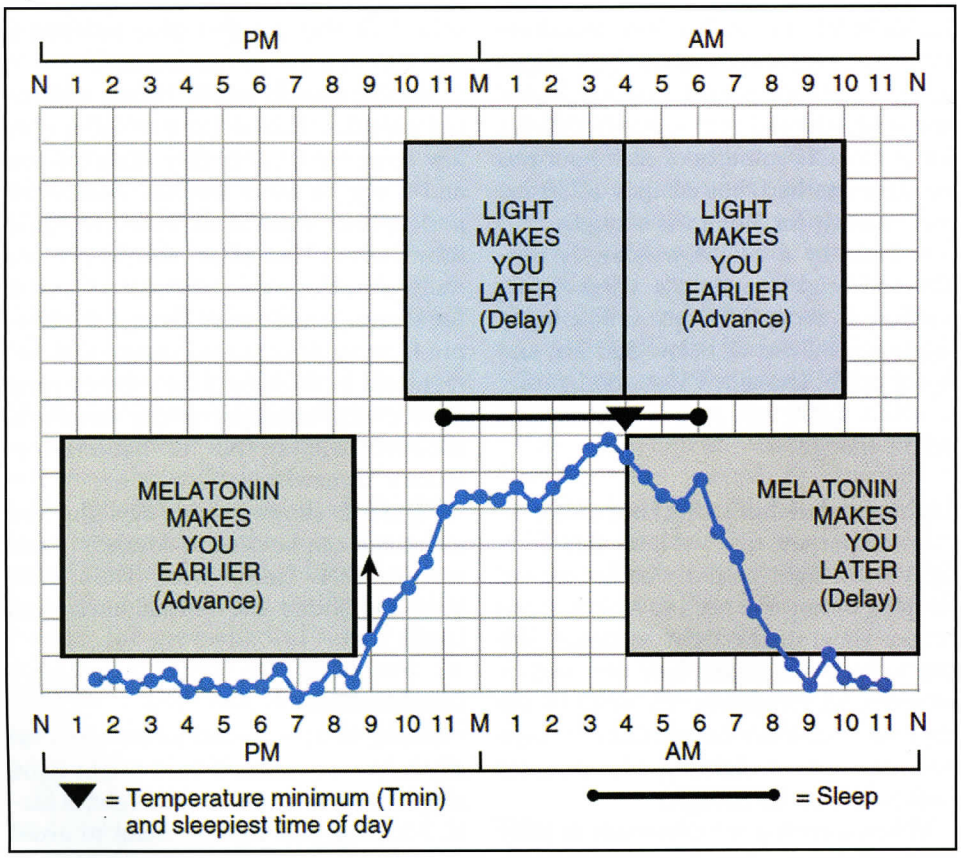
Dr. Charmane Eastman and colleagues of the Biological Rhythms Research Laboratory at Rush University Medical Center in Chicago, have published a very good series of research studies that demonstrate a strategy for best accommodation to jet lag and to nightshift work.

To oversimplify – I hope usefully – they show that the best strategy for night shift work is to move Tmin to a position shortly after arriving home from the night shift, and moving the days-off-work sleep period to a night-owl schedule, so that on work days Tmin occurs shortly after going to bed in the morning and toward the end of the sleep period on days off.

This is done with intermittent periods of bright light from about 12:00 or 1:00 am to about 5:00 am, and very dark sunglasses on the way home, where the bedroom has blackout shades. (Yes, Tmin *is* affected by bright light falling on a sleeper's closed lids.)

The research protocol used bright light the first 15 minutes of each hour for 4 hours, but it doesn't have to be so regular in practice.

Figure 2



Equipment

The **sunglasses** used in Dr. Eastland's research, safe for driving, are UVEX S1603 Bandit frames with Espresso blue-blocker wraparound lenses, available for $7-12. They transmit about 15% of incident light and the blue-blocker color distortion is safe for driving. The UVEX Genesis XC frame accepts a prescription-lens insert.

A similar lens that transmits true color is the UVEX SCT Gray lens, perhaps less desirable because blue wavelengths change circadian rhythms more strongly than the other colors. I mention this tint because no UVEX model that is designed to be worn over spectacles is available with the Espresso lens. The next best choice is the UVEX Astrospec OTG 3001(over the glass) frame with the SCT Gray lens.

Opaque goggles or masks are useful when traveling – search for "**sleep mask.**"

Bright artificial **light sources** used in jet-lag research are those used for **seasonal affective disorder**, as they're readily available and inexpensive. Looking at the research, it seems to me that 2500 lux for 2 hours or 10,000 lux for 30 minutes has about the same effect on moving Tmin.

Get a 5,000 – 10,000 lux SAD lamp and shine it on the pages of a fascinating book or important paperwork, or on your computer keyboard and desktop if you can't be outside in the daylight, walking, working, or at a sidewalk cafe. Small, portable lamps are readily available.

Melantonin should be 0.5 to 1 mg – and as it's not regulated in the U.S., be sure that it's rated "NF" or "national formulary," which means that the manufacturer at least claims to observe quality standards.

References and Acknowledgments.

How To Travel the World Without Jet lag, Charmane I. Eastman, Ph.D. and Helen J. Burgess, Ph.D.

Sleep Med Clin. 2009 June 1; 4(2): 241–255.

doi: 10.1016/j.jsmc.2009.02.006 PMCID: PMC2829880 NIHMSID: NIHMS166069

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2829880/ *Figure 1* is clipped from an illustration in this article.

Well written and clear; minimal jargon. Presents a very useful, practical strategy.

An updated article, differing factually only in some details, is published in **Therapy in Sleep Medicine**, Chapter 30: *Jet Lag and Its Prevention*, Victoria L.Revell, PhD and Charmane I. Eastman, PhD, Elsevier, 2011. *Figure 2* is from this chapter.

Jet lag and shift work sleep disorders: How to help reset the internal clock, Bhanu P. Kolla, MBBS and R. Robert Auger, MD, Cleveland Clinic Journal of Medicine, 2011 October 10, 78(1), 675-684

http://www.ccjm.org/content/78/10/675.full.pdf

Heavier on jargon, yet a good review if you know the lingo. Recommendations differ somewhat from Eastman and Burgess, probably due to reading the normal blur of research results differently.

Physiology of Circadian Entrainment, Diego A. Golombek & Ruth E. Rosenstein. *Physiology Review* 90: 1063–1102, 2010; doi:10.1152/physrev.00009.2009.

http://physrev.physiology.org/content/90/3/1063.full.pdf+html

Highly technical, but complete, written for the biomedical cognoscenti – for example, "Within the [supra-chiasmic nucleus], rhythms are generated in circadian pacemaker cells by a complex of molecular feedback loops that positively and negatively regulate the transcription of core genes (e.g., period, cryptochrome, bmal1) of the circadian clock." If you can handle the jargon, these authors are truly funny.

Acknowledgments

Many thanks to Dr. Charmane Eastman of Rush University Medical Center in Chicago for sending pdf copies of important relevant publications that I might not otherwise have discovered, and for reviewing and annotating my ante-final draft. Every deficiency of accuracy or language in this piece is mine. Honestly, this topic is exceedingly complex and difficult to simplify accurately.

Thanks to Chuck Coyne for letting me wander down this road for our magazine.

And thanks to my readers, who beat me up so helpfully.