Threat, Stress, and Pilot Performance

by Key Dismukes

People use the word "stress" in varied and often ill-defined ways. In this article I discuss a specific kind of stress, that which arises when we are faced with a threatening situation, and how it affects our ability to fly an aircraft.

Personal example

Very early in my flying career I moved to a new city shortly after completing my private glider rating. After six months of not flying, and with only about 35 hours total time, I went to a local gliderport to get checked out in a 2-33. At some point in the checkout the instructor gave me a rope break at about 300 ft. I should have been expecting it but I was quite startled. I turned back to the airfield and was lining up on final when the instructor said, "Watch your airspeed." I looked at the airspeed indicator, could see it clearly, but could not make any sense of the numbers.

Obviously I was under stress, but how could that disrupt such a simple task as understanding the numbers on an airspeed indicator? Fortunately there is a body of research addressing that question, which two colleagues and I recently reviewed and extended (Dismukes, Goldsmith, and Kochan, in press). The research literature goes back to WWII, in which a classic study found that navigation errors by Allied bombers increased as they entered enemy territory and peaked during combat opposition.

Stress and soaring

At the risk of oversimplification I will summarize the implications of some of the central research findings for soaring operations. Although situational stress can undercut many aspects of human performance, most of the effects seem to result from disruption of two crucial cognitive functions: attention and working memory. You may remember from my October 2015 *Soaring* article on aging that attention and working memory are narrow-band, limited-capacity "executive" processes that are essential for tasks that are novel, difficult, or dangerous – or any for any situation we must think through explicitly rather than just respond to automatically from previous practice.

You probably have an intuitive understanding of what attention is: focusing one's mind on one task, or thought, or stream of sensory input from a myriad of other possibilities. Basically, we can fully attend to only one stream of information at a given moment. If we are required to deal with multiple tasks, even though we may think we are performing them simultaneously, we are actually switching attention back and forth among the tasks somewhat like a spotlight.

Working memory is a tiny subset of your vast store of long-term memory, momentarily activated so that these few bits of information can be quickly accessed and manipulated. An example is retrieving a radio frequency from memory and holding it in awareness long enough to dial it in.

The experimental data on the effects of acute situational stress are consistent with a model proposed by Lazarus and Folkman in 1984. When we face a situation that is challenging and/or threatening we automatically orient both our physiological and our cognitive resources to deal with the situation. Physiological responses, such as increased heart rate and force, faster breathing, and restriction of peripheral blood flow, prepare the body for "fight or flight." Cognitively, the individual focuses attention on the challenging situation, mentally preparing for whatever may be required. Both physiological and cognitive resources are mobilized to deal with the situation. Up to this point the situation is considered challenging, but not necessarily stressful, because the individual feels able to manage the situation effectively, and performance may actually improve in this state of arousal.

However, if the situation becomes threatening, and the individual is uncertain of his or her ability to manage the threat, anxiety arises, with negative consequences. (The threat may be to physical well-being, social standing, or self-regard; one of the experimental manipulations used in research studies is to require individuals to give a presentation to a judgmental audience.) This anxiety, which is the underlying basis of acute situational stress, is maladaptive, undercutting task performance by disrupting both working memory and attention.

Anxiety intrudes on our attention in a way that is difficult to push aside, occupying much of the limited capacity of working memory, making it difficult to perform calculations we would normally find easy, such as computing the altitude we need to glide to a landout field. Attention is normally controlled by two brain processes. One process, called "top-down," directs attention in support of our current goals and enables us to switch attention back and forth in a controlled fashion among the several tasks involved in the current goal. For example, in my stressful simulated rope break so long ago, top-down processing should have directed my attention to move systematically among controlling the flight path, moni-

toring attitude (airspeed), and checking for other aircraft in the pattern. After I gained substantially more experience, all this would happen automatically and easily, but at this point I still had to think explicitly about each component task. Stress disrupted my ability to systematically direct my attention, and anxiety pre-empted some of my working memory capacity, making it difficult to compare the airspeed indications to the target airspeed stored in my long-term memory.

The other process controlling attention is called "bottom-up," referring to the way that environmental features grab our attention, directing it to cues that are salient, abrupt, or threatening. Normally the two processes work in a complementary fashion, the top-down one allowing us to focus attention and use working memory for the task at hand, and the bottom-up one allowing important environmental events to catch our attention when necessary. It would not have been good for early humans to become so focused on starting the campfire that they would be insensitive to rustling in the grass behind them.

Eysenck, Derakshan, Santos, and Calvo (2007) proposed that anxiety disrupts control of attention by shifting the balance between the two systems, giving greater weight to the bottom-up system. Consequently, attention is less under the control of task goals, and is more easily pulled away by salient cues or threatening aspects of the situation. Sometimes this causes the individual to focus too much on the most threatening feature of the situation and sometimes it causes his or her mind to flail about, unable to focus on any aspect. For example, a sailplane pilot getting very low on a cross-country flight might mentally lock in on trying to work an elusive half-knot thermal and fail to seek and evaluate off-field landing sites. Conversely, that pilot might find it difficult to focus on any one of the several aspects of a landing site long enough to evaluate it adequately.

Disruption of attention and working memory can undercut many aspects of pilots' performance. Pilots under high stress may find it difficult to perform mental calculations that would normally be easy and may have difficulty making sense of the overall situation and updating their mental model of the situation (i.e., situation awareness). My colleagues and I found that in airline accidents resulting from emergency situations, the most common category of crew error involved inadequate comprehension, interpretation, or assessment of the ongoing situation.

Stress is most disruptive in novel or unfamiliar situations; conversely, experience provides considerable protection against the disruption, for multiple reasons. Executing procedures that are highly practiced becomes largely automatic and much less dependent on our limited capacity of attention and working memory; consequently stress interferes less with well-practiced procedures. Also, if we have extensive experience with a broad range of situations in whatever kind of flying we do, when we encounter a threatening situation we do not have to mentally devise an entirely new solution; either we know this situation and can apply the solution from previous experience or we can adapt a previous solution to fit this new situation. Either way, the mental workload is considerably less.

Although I do not have research evidence to support this, I suspect that uncertainty plays a role in how much anxiety occurs in threatening situations. In a totally novel threatening situation

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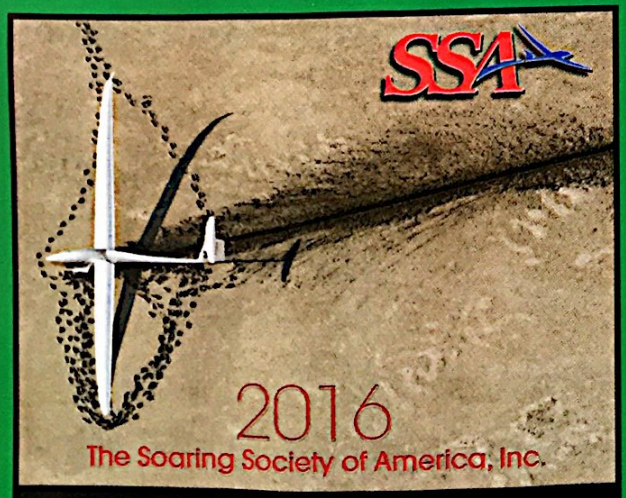

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we do not know whether we will be able to find a way out, but if the situation is at least somewhat familiar we may feel more confident and thus less anxious. Although I have felt some level of stress in every off-field landing I have ever made, over time I became more confident (and thus less anxious) that if I followed the rules I could make it work out.

Thoughts for managing situation stress

Anyone experiencing a threatening situation may become very aware of a pounding heart, rapid breathing, and rapidly darting thoughts. These physiological and cognitive responses may themselves be distracting and increase anxiety in an unfortunate positive feedback loop. It may help to reassure yourself you are not experiencing a heart attack, to breathe slowly and deeply, and to slow down and perform each action in an especially deliberate manner. In emergencies we have a natural tendency to rush and to flail around trying to accomplish everything at once. But in aviation it is rare for emergency situations to require instantaneous action. (Yes, of course, a stall in the landing pattern requires immediate action.) But rushing saves little if any time and increases error rates enormously.

A major way to reduce the intensity of stress is to thoughtfully develop the experience to deal with all aspects of a planned flight mission before embarking on it. For example, before starting cross-country flying it is crucial to read thoroughly and get instruction on all aspects. When I was starting out, whenever I drove in the country I would evaluate every field I passed for land-out potential and ask myself how I would set up the approach. (I still do this from time to time.) With such preparation, when the time comes to land out, mental workload is much reduced, appropriate decisions are easier, and the situation is much less stressful.

Experienced cross-country pilots build up over time an extensive knowledge base about flying out from their home field: best places to find lift, good and not-so-good land-out spots, obstacles and other hazards, etc. All this makes their flying in their home area safer and less stressful. But when these pilots fly from another soaring site for the first time they may mistakenly assume they have the same level of preparation and then find themselves very stressed upon stumbling upon an unknown trap, such as discovering on short final that an airport marked on the sectional is too narrow for a sailplane.

A large body of cognitive research reveals that having recently thought about something makes it much easier and faster to retrieve information about that thing from long-term memory. Thus, thinking explicitly before each flight about what you would do if the tow-rope broke at this altitude or that altitude makes it much easier to retrieve the proper response from memory quickly and to execute it correctly.

Finally, wherever you fly, during each phase of the flight, always, always have a way out, a plan B if what you are doing doesn't work out, and maybe even a plan C. "What are my options if that nice looking Cu 10 miles out dies before I get there?"

Obviously, all of these suggestions are important ways to support flying safely. The connection between operating safely and limiting stress levels is not at all coincidental.

About the Author: *Key Dismukes retired as Chief Scientist for Human Factors at NASA Ames Research Center. His research addressed the ability of experts to manage challenging situations, error vulnerability, risk management, prospective memory, attention management in multitasking, and learning and memory. He holds ATP, B737 and Citation-type, and glider instructor ratings and received the 2013 Laura Tabor Barbour Air Safety Award.*

Further Reading

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