Cognition, Aging, and the Soaring Pilot

by Key Dismukes

Matt Herron's article in the September 2015 issue of *Soaring* reminds us we should be thinking about whether we can continue to fly safely as we enter our senior years. Fortunately, several large research literatures provide information that can help us make that assessment wisely and help us extend our flying time as much as can be done safely. I do not have space in this article to discuss those literatures in detail or technical depth; rather I will give you a high-level summary and raise some questions to think about. Let's start with this one:

True or false? "I continue to hold an FAA third-class medical and had a recent flight review with a CFIG, so clearly my flying is not at risk, even though I am 76."

Well, maybe, maybe not, let's see.

What I will talk about here is called normal aging, the inevitable changes that affect us all throughout our lifespan but which usually do not become serious challenges until the last several decades of life. In many ways it is the normal aging changes – particularly changes in cognition – that are the most insidious, affecting us all in subtle and complex ways we may overlook or may assume will not affect our flying.

(You young whippersnappers, do not think this is a topic you can ignore for many decades; some important cognitive functions begin to decline even by our thirties, which is why mathematicians typically do their best theoretical work in their twenties.) I will not talk about age-related pathologies or changes in vision and hearing, subjects treated in Dr. Dan Johnson's superb monthly columns.

Cognition refers to how the brain/mind takes in, processes, and uses information to perceive, remember, think, and take action. Many aspects of cognition have been studied extensively, but one particular distinction is especially relevant to piloting performance. We speak of two basic modes of cognitive processing: *executive* and *automatic*. Age affects these two modes differentially.

Executive processes, closely associated with attention, working memory, and deliberation, are slow and effortful. These processes operate serially (one step at a time) and can handle only a very small amount of information at any moment. Executive processing is required when we are learning new skills, dealing with novel or difficult situations (e.g., dealing with a jammed aileron), planning future activities, or solving problems. Dealing with emergencies, equipment failures, or high workload situations is challenging in part because these situations often overwhelm the limited volume of information our executive processes can process at a time.

In contrast, automatic processing develops over time from practicing specific tasks repeatedly. It is fast and efficient and requires little mental effort, and in most situations is robust and reliable. Automatic processing underlies humans' extraordinary capacity for recognizing familiar patterns.

Think about when you were first learning to drive a car or fly an airplane. Initially, it was difficult to keep up with all that had to be done, to perform each sub-task smoothly and correctly, and you probably found the mental effort required to be quite high. But over time, as you became proficient, the various tasks seemed to become easier, eventually stick and rudder coordination seemed to happen without trying very hard. Actually, the tasks themselves did not change, what happened is that with practice automatic processing took over, procedural memory guided action, and much less executive processing was required. Performance became smooth and fluid and you were able to think about other aspects of flying while manipulating the controls. (Hmm, is that dry lake a good landout spot?)

Piloting involves diverse tasks which require differing combinations of skill, knowledge, and thinking, and thus draw upon executive and automatic processes to different degrees. Stick and rudder skills, with practice, become largely automatic, but managing unfamiliar situations, dealing with emergencies, solving problems, and juggling heavy workload depend heavily on the executive mode. Decision-making lies between the two modes. It can be fairly automatic when dealing with familiar situations, such as when to deploy spoilers in the landing pattern. But in other situations, such as judging how far to penetrate into a circle in a contest turn area task, decision-making draws heavily on executive processes.

Aging affects automatic and executive processes quite differently. The good news is that automatic processing is fairly resilient to aging; consequently well-learned stick and rudder skills can remain quite high with consistent practice even in our eighties. The not-so-good news is that executive processing inevitably declines with age. Information-processing speed slows down, and the rate at which we can take in and learn new information slows down. Multi-tasking ability, reasoning, problem-solving, and recall of factual information all decline substantially. Consequently, an older pilot may perform superbly on a vanilla flight review but be at risk in seldom-practiced situations and under high workload.

The decline in executive processes actually starts in our twenties, though typically we do not start noticing it until we are in our early sixties, by which time the amount of loss is substantial. But wait a minute, perhaps you are saying, this does not square with real-world experience; I know that professionals in many domains perform quite well long past their sixties. Pablo Casals and Arthur Rubenstein, for example, gave profound performances well into their eighties.

Several reasons account for this apparent difference between the well-documented decline of measurable executive functions throughout adulthood and the impressive performance of some individuals until late in life. In youth, we probably have considerable cognitive reserve; most tasks do not require maxi-

mum cognitive ability for prolonged periods (theoretical mathematics being one clear exception). And of course, cognitive ability is only one factor; even in intellectually demanding professions, other factors, such as motivation, are important. Also, as individuals age, they often modify their activities to make them less demanding; older drivers, for example, often stop driving at night or in heavy traffic.

Perhaps most important for preserving performance in the face of declining cognitive ability is the role of experience. For example, a low-time cross-country soaring pilot faced with an imminent landout may find the mental workload of assessing potential landing fields quite high, not to mention stressful. In contrast, a high-time soaring pilot may draw upon extensive experience in similar situations, automatically retrieving from memory the best action for the situation. For this experienced pilot, the mental workload is much lower, and perhaps the stress is less because he or she knows that the situation can be handled. (Look for a later article on the effects of stress on pilot performance.) Fortunately, pilots – like all skilled experts – can build up an enormous body of domain knowledge and procedural skills over time.

Thus, we have a trade-off: the long, slow decline of executive processes over the decades versus the steady growth of experience for those who practice their craft consistently. At some point, inevitably, the two curves cross, and the net result is eroding ability. Where exactly the two curves cross varies greatly with the individual, for several reasons. The rate of decline of executive processes differs substantially among individuals and is affected by genes, physical health, exercise, diet, mental activities, and social engagement. And of course individuals vary greatly in how much and how consistently they practice their skills over the years. Clearly, a pilot who has flown a great deal every year throughout adulthood is much better protected against age-driven deterioration in performance than pilots who fly only sporadically. The upshot of all this is that no one-size-fits-all rule can tell us when it is time to stop flying or even when we should start changing the kind of flying we do.

One might think that aviation accident rates would tell us much of what we need to know about the effects of age on pilot performance. A fair number of studies have examined accident rates as a function of age, but unfortunately, these are of limited help for those of us in the 60-90 age range. It is difficult to separate out all the factors that co-vary with age, and the few well-designed epidemiological studies have focused mainly on the age at which to require airline pilots to retire. Even epidemiological studies of accidents have not taken into account the changes that older general aviation pilots often voluntarily make in the extent to which they fly in challenging situations.

More informative for us are the studies that have examined pilots' performance in flight simulators, comparing groups of pilots of different ages (cross-sectional studies) and also following changes in individual pilots' performance over time (longitudinal studies). The effects of age and experience have been examined on pilot performance aspects such as accuracy of following ATC instructions, aircraft control accuracy during approach in a cross-wind, appropriate land/go-around decisions in IFR, scanning of cockpit instruments, and avoiding conflicting VFR traffic. Even these simulation studies have inherent methodological limitations: only moderate fidelity simulators have been available, only a limited range of pilot tasks have been examined, and no studies of soaring performance have been published (to my knowledge). However, the data, which are fairly consistent across studies, are relevant to all pilots, so let's briefly review two of these studies.

The most extensive of these simulation studies has been conducted over a period of more than ten years by a team at Stanford University and the Veterans Administration. In one of their reports Taylor, Kennedy, Noda, & Yesavage (2007) compared performance of pilots in age groups 40-49, 50-59, and 60-69 at three different levels of experience: VFR-rated only, instrument rated, or instrument instructor/airline transport pilot (CFII/ATP). The performance of each age group was substantially lower than that of the younger groups, but in all three age groups the more experienced pilots performed better than those less experienced, partially compensating for the effect of age. In fact, the CFII/ATP 60-69 group appeared to perform as well as less experienced pilots in the 50-59 group. In a related study, Yesavage and his colleagues (2011) found that pilots with higher scores on laboratory tests of information processing speed and executive function showed reduced decline of simulator performance over the four years they were studied.

The upshot of all this research is that, yes, we senior pilots should be concerned with our ability to continue flying safely as we age. We are especially vulnerable in situations that combine unfamiliar aspects, high workload, time pressure, and high consequence of errors. Most at risk are older pilots with limited experience and low currency. But keep in mind that, regardless of flight experience, risk varies substantially among individuals; further, the level of risk varies considerably for

each individual as a function of the specific task being performed.

There is some good news. Our acquired knowledge (the best place to find a thermal when getting low) and procedural skills (getting the most out of every turn in the thermal) can grow throughout the lifespan (though not as fast in our senior years). When not under heavy workload, older pilots can shine at judgment and decision-making because of our experience with a broad range of situations, and – one hopes – we become less impetuous as we get older.

So, what's an old geezer pilot like me to do?

Several things can keep us flying longer with acceptable levels of safety. First, exercise regularly; a large body of research shows that consistent exercise slows the effects of aging, in part by keeping the flow of oxygen to the brain open. A healthy diet also helps, as does working with your physician to stay on top of medical issues. We should continuously self-evaluate our performance in both routine and challenging situations (not a bad idea for pilots of all ages!), and stay extremely current. Depending on that self-evaluation we may find it wise to gradually reduce our exposure to high-workload, time-pressured situations and reduce the complexity of the type of flying we do.

Cultivating a deliberate, systematic approach to everything we do around airplanes and using checklists religiously can help protect us against distractions, tunneling of attention, and forgetting to perform critical actions. When taking passengers up, tell them about the "sterile cockpit" rule to prevent distracting conversation during critical phases of flight such as take-off and landing. Extend the concept of the sterile cockpit rule to rigging and performing the positive control check. These protective measures can help all pilots avoid making errors, but they are especially important as we get older.

How do I know when it's time to stop flying solo?

There is no simple answer to this question. You might consider keeping a self-appraisal log: track instances of getting behind the airplane, getting confused, not noticing things, or forgetting to do things, minor incidents, etc. We all experience occasional incidents like these even when young; the point is to keep track of the trend. And keep track of the good stuff too, to put it all in perspective.

Fly with a CFIG more than every two years. The FAA requirement for flight reviews is ridiculously inadequate. Airline and military pilots train much more frequently. Performing adequately on a typical flight review will not necessarily expose the subtle impairments to executive cognitive functioning associated with age; these impairments may show up only in challenging and unpracticed situations. Thus, we should ask our flight instructors to challenge us meaningfully. (I know, I know, as an instructor myself, I hate nothing more than having another instructor point out my deficiencies; we just have to put our egos aside.)

Finally, at some point, we may want to ask: **has it stopped being fun?** An honest answer to this question may help avoid a world of hurt.

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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