SOARING Rx

BY DR. DANIEL L. JOHNSON

Choosing Spectacles for the Aging Eye

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

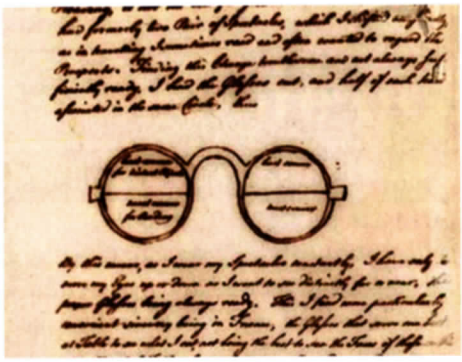
The eye is a very-wide-angle compound adaptive optical system comprising two complex lenses and a high-resolution photosensitive surface.

There are two things that we glider pilots really need to see: the airspeed indicator and the outside stuff.

Bart is discovering that the instrument panel is too close to see clearly, and the chart, which he never bothered to study, has gone from unnecessary to useless because he can't see the words, anyway. What's happening?

The young, normal (*emmetropic*) human eye can focus sharply on everything from 4 in/10 cm to infinity. This wonderful accommodative power is gradually lost during adulthood. Eventually we can't shift focus between the checklist in our hand and the hawk above the field.

This is not only annoying, it's unsafe. Fortunately, about 285 years ago, Benjamin Franklin did the obvious thing – cut two lenses in half and wired them into a single spectacles frame. Thus was the bifocal invented. Today, this design, in which a line crosses the entire lens horizontally, is called an *executive* lens.



Franklin bifocals manuscript

(Pedantry alert: some people restrict "Franklin" to bifocals that use 2 separate lenses top and bottom.)

The lenses of the aged person are essentially frozen, and do not accommodate at all. Such folks generally like the progressive lens because the part of the lens giving clearest vision for a particular target can be used with head and eye movement.

The younger presbyope has simply lost accommodative *range*. These folks may function best with a low-power executive bifocal that simply divides the lens into a part suitable for closer vision and a part suitable for more distant vision.

Ironically, it is the younger presbyope who is less willing to show up at a party with a line across the glasses.

If Bart is one of the half of the population with good distance vision, he can pick up a pair of "reading" glasses at the drugstore for less than ten bucks. He can buy plastic half-lenses that will slip onto the inside of his sunglasses (or prescription glasses). Google up "stick on reading lenses." Or Bart can visit a Vision Professional for a pair of $800 Super-Duper spectacles.

Special Bifocal Needs

If you waltz into your local optical shop and just ask for glasses, you will be prescribed a pair designed to shift your gaze from the map in your lap to the road signs, and see each clearly.

Many of us have needs different from this. Your optician can serve you best if you have first observed (and measured), for important tasks, the distance at which you need clear vision, and the part of your glasses through which you are looking at that moment.

For example, you can sit in your cockpit wearing an old pair of glasses, or cheap sunglasses, and with your head and eyes gazing in the normal direction and posture, simply draw a line with a marker on each lens matching the edge of the panel. (Yes, it will look very blurry.)

You will not be able to buy spectacles in which the bifocal segment is the exact shape of your panel, but this will be a good guide to the placement of the intermediate-vision segment in your glasses.

(This strategy of positioning and measurement is obviously helpful for buying glasses in any special situation.)

Then measure the distance from your eye to the panel in meters (d). The power in diopters of a lens that will bring your focus from infinity to the panel is 1/d. You will probably not need a bifocal power aimed at bringing the panel exactly into focus – it simply needs to be within your accommodative range while using that segment.

The great advantage of the executive bifocal is that you have clear corrected vision at the working distance across the

entire lens. This is not true of the bifocal in which the near-vision lens is inserted into a small portion of the larger lens. It is even less true of the *progressive* lenses, which have sharp vision only in a tiny central area called the *corridor*.

Tips about Buying Progressive Lenses

It's been my experience, as a long-time presbyope, that most opticians either do not understand the optical science and design of the lenses they sell, or they prefer not to take the extra time required to individualize spectacles. Thus, your leadership, preparation, and initiative are important in obtaining useful progressive spectacles.

The first question is, in thinking about the environment in which you're using them, *do you need to see infinity at all*? That is, do you need to see clearly anything farther away than the clock on the opposite wall? My experience indoors is that a sliver of distant vision correction across the top of the lens is useful for unexpected times, and that this can be pretty narrow and be helpful.

The second question is, in thinking about the use environment, *how far away is the nearest object requiring good focus* and *how much accommodation do you have remaining*? Answering this question allows the optician to determine how much "add" to specify in the near-vision segment.

During my medical student years I recall watching a polite debate between a persistent elderly woman and her very frustrated ophthalmologist. He was unable to comprehend why she could possibly be dissatisfied with her current bifocal (he had prescribed what he *thought* she needed) and she was unable to articulate that she could not see the thread as she put it into the eye of the needle when she sewed.

Severely nearsighted people (i.e., with high *myopia*) can thread the needle just by looking around the rim of their glasses. People who are farsighted (*hyperopic*) can see nothing close without a lens. Such people often do much better with a loupe, particularly seamstresses and jewelers.

The third question is, "*what is needed for intermediate vision?*"

Honestly, this is where the aging person finds the most challenge in finding sweet spectacles. Perhaps this is because our culture has transitioned from books-or-outdoors to computer-or-TV. For some people, most of the visual day is spent in the intermediate visual range.

This means, I think, one pair of glasses for work and home, another for flying and driving.

Style Points

Some people feel about a line on their glasses the same way they feel about carrying a crutch in public.

Exactly what we buy depends partly on whether we would rather see or be seen. It is easier to provide high-quality optics in a large lens. This is a very nice window, yet we look like we are wearing goggles.

Wide and very narrow lenses have been popular for the last decade. These are in contradistinction to the fact that our eye is a very-wide-angle camera. Regrettably, it is impossible to put a highly functional corridor in a squat progressive lens. This is called a short corridor, and the advertising is explicit about style and silent about limitations.

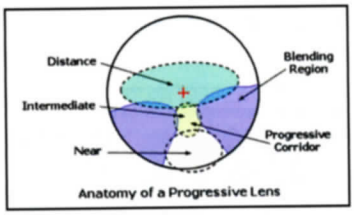
It is my experience that it is all but impossible to find out, either on the Internet or from an optician, just how wide is the corridor and what its position is on any particular lens. It is hard to convince an optician to position a segment at a different location than usual. It is extremely difficult to understand how to communicate one's needs for a progressive lens. This is not because opticians are stupid: it's because the choices are complex and many, and no optician can be familiar with all the brands.

Internet sites are not very helpful. For example, when I sought a wide corridor for intermediate distances, after spending $100s on glasses that were falsely claimed to have a wide corridor, an optician suddenly exclaimed to me, "Oh, you want the Zeiss 'Officelens'!" He explained that this is designed for indoor work, to have sharp vision for reading, and a wide corridor for a drafting table or computer. He was right about that.

He said that it has no distance segment. He was wrong about that – the top 5mm or so is a distance segment, just enough to drive safely when I have forgotten to change glasses. There are other brands of wide-corridor progressives, as you can discover to your own confusion with Mr. Google's help.

The difficulty with progressive lenses is that the optics are slightly blurred on both sides of the corridor. This may be fine at the office or at home, and perhaps on the golf course. In the cockpit, this does not seem like a good idea. Which part of the sky should look blurry to you? Right. I feel the same way.

Having said that, the blur at the sides, euphemistically called "the blending region," is, if you have a small correction, much less and may be trivial.



Anatomy of a Progressive Lens ~~(part of image already)~~

Why Are Bifocals Hard to Adjust to?

I'll spare you the book. First, for some people, bifocals are their first spectacles. Many people have subtle optical defects which their perceptual system has long ago factored out. The perfectionistic professional prescriber of specs meticulously corrects these, and then the brain and eyes tug hard at the revised image, working hard to adjust to the wrinkles that are now absent except when the glasses come off.

Second, classic bifocals have a line, across which images jump. And through the reading lens your feet and the steps look bigger & closer. (Touch the handrail & go down by feel, please.)

Third, with progressives, the sweet spot of sharpest vision for each distance may require rather precise head position that may be impossible under the sink or the panel.

The Optics of the Eye

The eye is a wide-angle imaging device using two compound lenses. One is the *cornea*, a meniscus lens with a high refractive power of 48 diopters. The refraction of light occurs at the surface of the lens, as light passes from one medium into another. In land-dwelling animals, light passes from air into corneal tissue. The corneas of fish must bulge because the refractive index of water is 1.32, greater than that of air, which is 1.0003.

The second lens of the eye is what we normally call the "lens." This lens accounts for about one third of the optical power of the eye. Its refractive power changes from about 21 diopters when viewing infinity to more than 30 diopters when fully accommodated for near vision.

The front surface of the lens is flatter than the back surface. Interestingly, the human lens has a "gradient index structure" in which the refractive index increases from the outer surface to the center.

The curvature of the retina closely matches the curvature of the focused image upon it. This is important in maintaining good peripheral-image acuity. Each retinal rod acts as an individual waveguide, pointing to the center of the pupil. This increases each rod's efficiency, increasing sensitivity to the focused ray and decreasing sensitivity to scattered light.

When we gaze at infinity, the lens relaxes and is flattened. When we focus on a near object, a doughnut shaped muscle, the *ciliary body*, tightens around the lens, making it bulge. (Fish and amphibians accommodate by moving the lens fore and aft, as a camera does.)

Most resilient things in our bodies become stiff with age, including this lens. This means that our accommodative range gradually decreases with age. In grade school, we can accommodate about 15 diopters. In college, we can accommodate about 10 diopters. By the time our children are in school we can only accommodate about 5 diopters, and by the time we have grandchildren it's down to about 1 diopter.

This is the progress of presbyopia. This may be yet another result of our Western diet, as some long-lived populations eating a diet based in plants, supplemented by modest amounts of lean protein, do not develop limiting presbyopia. This dietary news comes too late for most of us.

Why Is Myopia Common?

The eye is about an inch in diameter. The main structural difference between farsighted and nearsighted eyes is length. In adults under the age of 40, farsighted eyes average 22.6 mm, and nearsighted eyes average 25.2 mm.

Most babies are born farsighted, yet the tremendous accommodative power of children provides good focus on the retina. In adulthood, people of highly literate countries have much more myopia. Studies have shown that close work in childhood tends to bring about elongation of the eye, and increases the incidence and severity of myopia.

A solution would be to use reading glasses for school work and homework. In my experience, parents are not interested and children are opposed.

The Eye as an Optical Instrument

As a camera, the human eye is a 130 megapixel sensor containing a variable-focus lens and an iris that ranges from f2.5 to f10. But the eye is not a machine: it is a dynamic, responsive organ in a growing and developing individual. It does not produce images, it sends pre-analyzed sensory data to higher centers for perception. In childhood, retinal blur and visual tasks modify its growth and development.

Few eyes are optically perfect. The great benefit of spectacles is that both gross and subtle optical errors can be corrected to provide clear vision, yielding safer and more effective perception.

As we age, the shape and function of the eye become stable, and each person adapts to the eyeballs we have. As we enter old age, the clear parts of the eye tend to acquire fog and grime, decreasing the sharpness of our vision. The traditional remedy for this stiffening lens has been that of Ben Franklin.

Spectacle Avoidance

Other remedies are being invented, such as corneal refractive surgery for reading distance in one eye and distant vision in the other. For people with cataracts, it is now possible to implant artificial lenses that can accommodate somewhat. Other approaches exist as well, and I will spare you the catalog. I mention this list in case you want to take an exploratory walk on the Internet.

The important thing for pilots is to explore carefully how any of these newer remedies will alter perception, and whether they may hinder the high visual functioning we need in order to see other aircraft. This is more important than whether the FAA is willing to issue a medical certificate based on successfully squinting well enough to make out the 20/40 line on the eye chart.

For remedies involving surgery, it is also very important to understand what the potential adverse outcomes are and what the real risk of one happening is. No operation is universally successful.