FLIGHT SAFETY FOUNDATION
HUMAN FACTORS & AVIATION MEDICINE
Vol. 42 No. 5 *For Everyone Concerned with the Safety of Flight* September–October 1995

Cockpit Crew Members Can Overcome Common Eye Problems

Irregularities in the eye often hamper correct focusing, but corrective lenses can compensate for most typical eye problems.

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Nearsightedness, farsightedness, astigmatism and presbyopia are caused by errors of refraction of the lens and cornea of the eye. Although these conditions degrade vision, the problems can be overcome with refractive lenses. With proper care and protection, eyesight can continue to impart useful information for even a longer-than-average life span.

To understand nearsightedness, farsightedness, astigmatism and presbyopia, it is necessary to review the mechanism of eyesight.

The human eye, although often compared with the film camera, is much more sophisticated than any camera. Each day a person's eyes must move and focus on subjects near and far in a variety of lighting conditions to provide detailed three-dimensional images.

The eye (Figure 1, page 2), a complex, yet compact organ, is protected by its location in the skull and by the eyelid. The opening and closing of the eyelid protects the eye from high-intensity light, foreign matter and impact. Tears, which are spread when the eyelid opens and closes, clean and lubricate the eye.

Six external muscles move the eye. The human eyeball is spherically shaped so that it can rotate up and down and from right to left, as well as in combinations that create circular sweeping motions.

At the front of the eye is the cornea, a tough layer of clear tissue that provides the majority of the eye's focusing power. Most of the focusing power in the unaided eye is derived from the curvature and characteristics of the cornea. Light enters the cornea, which directs it through the pupil and the lens to the retina at the back of the eye.

In bright light, the pupil — the dark center of the eye as seen from the front — becomes smaller in diameter to reduce incoming light, so that the light-detecting cells of the retina are not overpowered. The iris (the colored ring around the pupil) enlarges and contracts the pupil. Contracting the pupil adds focusing power, which is why tiny objects can be seen more clearly in bright light than in dim light. In dim light, the pupil becomes enlarged, which allows more light to be gathered but decreases focusing power. (Middle-aged pilots often first notice the need for reading glasses while flying at night in a darkened cockpit).

The lens tissue is suspended by fibers in the middle of the eye. This lens changes shape to focus light rays through the colorless gel-like substance behind the lens and then onto the retina — the eye's "film" — the layers of tissue at the rear of the

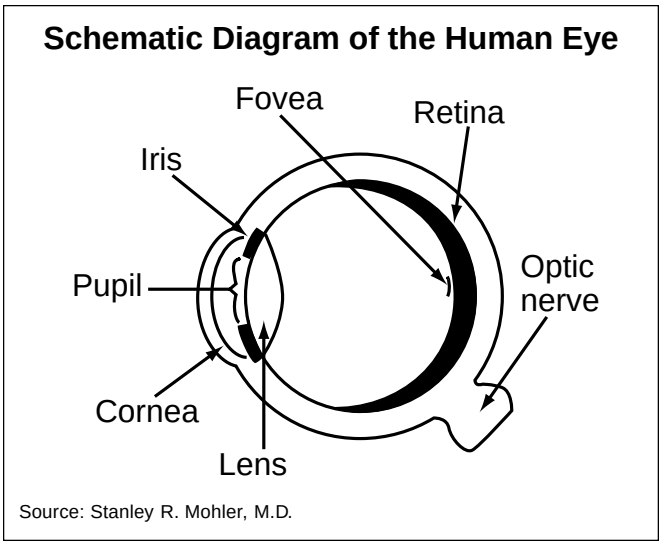


Figure 1

eye. When the eye focuses on a subject that is near, the lens thickens (rounds), and when the eye focuses on a subject that is distant, the lens thins (flattens).

Cockpit duties involve scrutinizing paperwork that can contain print smaller than newspaper print. A certain degree of focusing power is required for this; less focusing power is needed for the intermediate distance to the instrument panel and still less for the distance at "infinity."

A person with "20/20 vision" can see, on the standard Snellen eye chart at 20 feet (6.1 meters), a letter or symbol of a prescribed height.[1] As the eye of this person views an object from approximately 20 feet, the lens of the eye is in a relatively flattened state. As the eye views subjects that are closer, such as a cockpit instrument display, from three feet (0.92 meter), the lens becomes somewhat more rounded, increasing its focusing power. As a printed page is moved to within 14 inches (36 centimeters) of the eye, the lens becomes even more rounded to focus the letter or symbol.

Retina Contains Rods and Cones

The retina receives the individual photons of light that have passed through the lens and the clear material between the lens and the retina. Two types of cells are contained within the retina.

Light is perceived by rod cells, while light and colors are perceived by cone cells. Cone cells — which constitute only about 5 percent of the retina's light-responsive cells — need more light to function than do rod cells, which partly explains why colors are less visible in the dark. Light causes the rod and cone receptors in the retina to "fire," sending electrical impulses through the optic nerve to the brain, where a specialized center called the visual cortex converts the electrical messages into what is experienced as size, shape and motion. These images are also transmitted directly through the spinal cord for reflex actions needed for protection, or other reasons, prior to conscious recognition of the visual signal. Retinal signals help keep the eye locked onto a viewing point and also help modify the lens shape to retain focus.

The most common eye problems are the result of refraction errors of the lens and cornea. To see clearly, correctly focused light must reach the retina. To accomplish this, the length of the eyeball must be coordinated with the focusing power of the lens and the cornea. If they are not coordinated, the light can be in focus in front of the retina — *nearsightedness* — and only near subjects will be focused correctly (Figure 2). If light is focused behind the retina — *farsightedness* — only distant subjects will be focused correctly. If the cornea is shaped irregularly, a refraction error known as *astigmatism* results and some light will be misdirected and cause blurring. These three conditions can be inherited. *Presbyopia* also causes refraction errors. As a person ages, the cells in the lens are compressed when they die, lessening the elasticity of the lens. The presbyopic eye cannot focus clearly on near subjects because its lens no longer can round itself for near focus.

Blurred vision of distant subjects is a symptom of nearsightedness (myopia). Severe nearsightedness can limit clear sight to subjects only a few inches from the eye, while mild nearsightedness might not interfere with clear vision for several yards from the eye. This condition is treated with corrective lenses (eyeglasses or contact lenses) that have concave lenses. Nearsightedness often begins in childhood but stabilizes in young adulthood, and lessens the need for changes to corrective lenses. But by middle age, the normal effects of aging also begin to change vision.

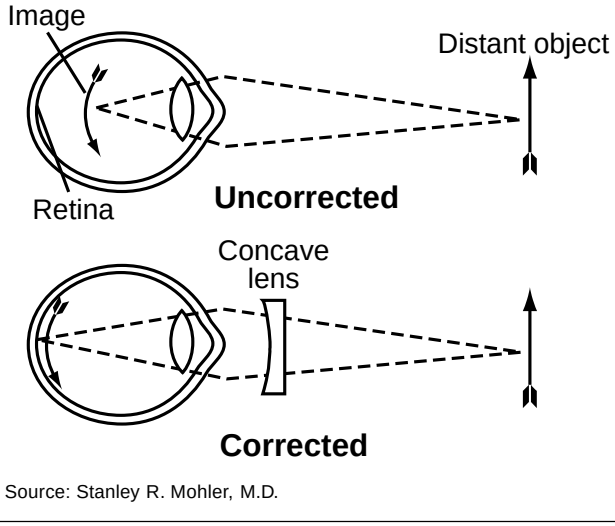


Figure 2

By about the age of 40, many persons with have slowly extended their distance for reading to an uncomfortable two and one-half feet to three feet (0.76 meter to 0.92 meter). Nearsighted persons may not notice this gradual change, but while wearing their corrective lenses for distant vision, they may need a close-vision correction (convex) added to the lower part of their corrective lenses — thus, bifocal lenses — to achieve adequate close-focusing power. Of course, many nearsighted people will continue to read fine print without corrective lenses, even though their own near point — the distance for working, reading or other close activity — of a few inches may have now moved to 18 inches (46 centimeters) or so.

When the near point of the eye begins with age to recede past approximately 18 inches (46 centimeters), eye fatigue is best avoided by obtaining proper refraction. For those with normal distance vision, bifocal reading glasses provide suitable visual power. Over time, additional lens power for an individual will be necessary. Annual eye examinations are therefore recommended. Eye examinations can be obtained from either an ophthalmologist (a physician specializing in eye care) or an optometrist (a professional licensed to prescribe corrective lenses).

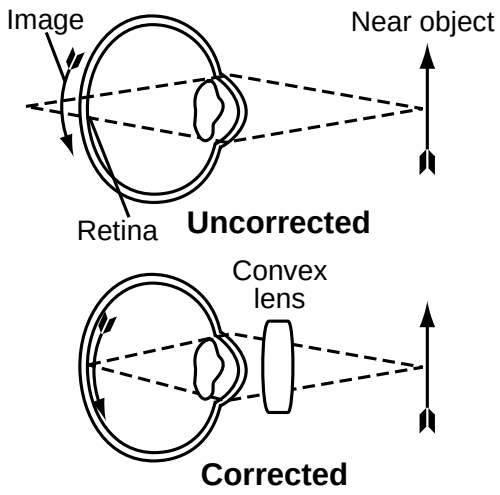
Convex Lenses Restore Small-print Vision

Flight crew members who in their 20s and 30s do not need corrective lenses will, through the normal aging process, find that small print becomes difficult to read in dim light somewhere around the age of 40. With brighter light, the constriction of the pupils helps focus the retinal image, allowing those in early middle age to read easily. Nevertheless, with the passage of a few more years, even bright light will not help. The solution is to have a convex lens prescription, either through eyeglasses or contact lenses, with correction tailored to the individual. This will bring small print into focus, even in dim light.

A surgical technique, radial keratotomy, has had some success in correcting mild to moderate myopia. Nevertheless, aviators should be cautious in electing this course, because its long-term benefits are not yet understood fully. Moreover, this procedure might not be accepted by some civil aviation authorities, who might deny medical certification for commercial pilots.

Blurred vision of near subjects is a symptom of farsightedness (hyperopia). Eyestrain, including aching eyes and headaches, may be present after performing close tasks such as reading and writing. This condition is easily treated with corrective lenses that have convex lenses. Although not widespread, there are some surgical techniques used to treat farsightedness, but aviators should also be cautious about this form of treatment.

Uncorrected and Corrected Presbyopia Of the Eye



Source: Stanley R. Mohler, M.D.

Figure 3

Blurring of vertical, horizontal or diagonal lines is a symptom of astigmatism, which is usually present from birth and tends to remain relatively constant even with aging. This condition is corrected with prescribed lenses that counteract the irregularly shaped cornea.

Dim Light Reveals Presbyopia

Decreased ability to focus on near subjects and eyestrain are symptoms of presbyopia (Figure 3). A flight crew member will normally discover developing presbyopia in dim light during night flight, when charts and printed material become less clear to the unaided eye. This phenomenon develops at middle age.

Presbyopia is usually treated with corrective eyeglasses with convex lenses, which may have to be changed every few years as the eyes' lenses gradually lose their ability to adjust. By the mid-60s, the eyes' lenses will have little accommodation remaining, therefore prescription changes will be less frequent.

Corrective lenses for near vision can be "half-moon" glasses (spectacles). They can also be full-size glasses with just the bottom parts having refractive power for close work.

Persons who need more than one kind of correction can wear eyeglasses with two lenses (bifocals) or even three lenses (trifocals) rather than wear different eyeglasses for each condition.

In bifocals, the top lens portion is corrected for distance and the bottom lens portion is corrected for near subjects. Trifocals include a middle lens portion corrected for focusing at arm's length. Some practice is required to become accustomed to bifocals and trifocals, and correct fitting of eyeglasses is essential.

Contact lenses are now available as bifocals. These contact lenses are weighted at the bottom so that a bifocal element can be stabilized in one place.

Some Conditions Require Protective Eye Wear

Certain practices help protect eyesight at any age. To protect the cornea, it is useful to wear glasses in windy or dusty conditions, or when the air contains other harmful elements. Special protective eye wear is necessary when a person is using tools, or is around toxic chemicals or gases.

Sunglasses are an important protection against lens and retinal damage from radiation. The fovea, the part of the retina that is sensitive to fine detail, movement and color, can be especially damaged by light that exceeds a certain energy level. A person should never stare at the sun and should always wear protective goggles when doing any kind of welding. Too much light energy without protection will burn a hole in the fovea if focused on this area. Blue-blocking yellow or amber lenses help protect the fovea from high-frequency light energy.

Regardless of whether a pilot operates under "see and be seen" conditions or under instrument flight rules, his or her eyes are essential tools of the trade. Being sensitive to gradual changes in vision and having regular eye examinations will ensure that appropriate measures can be taken to detect and counteract any problems that arise. ♦

Reference

1. Dhenin, G. (ed.) *Aviation Medicine, Health and Clinical Aspects.* London, England: TriMed Books, Ltd.: 25.

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