Those who are hypertrophic can use the eye muscles to bring distant objects into focus, so that it is only those with extreme hypertrophia that need glasses to perform normal living tasks. (As they get older and lose the ability to focus their eyes, they will need glasses for reading. They too will often not be aware that their distance vision has deteriorated and that glasses could improve their vision dramatically) Persons of any age with hypertrophia who look at a blue sky with gliders or aeroplanes in it will not see the obstacles until they are quite close (perhaps only 1 km away) because the at rest eye image is too blurred for the autofocus mechanism to work.

In summary, about 10% of us do not need any glasses for flying, about 20% of us are so shortsighted that we already have glasses, and the rest of us think our eyes are normal and do not realise how much more we could see with appropriate glasses.

The message is clear. Go to an optometrist or opthalmologist, tell them you are a pilot and that distance vision is critical to your safety, then ask them to test your eyes. Get glasses unless your at rest eyes focus on infinity.

When you have glasses, keep them clean. Any smears of sunscreen on the lens can cause the autofocus mechanism to try to focus on the smears, making the distant vision blurred.

Sunglasses

There are numerous reasons why pilots should wear sunglasses when flying. These include:-

- Protection from ultra-violet light damage. UV is a cause of cataracts.
- By filtering out some of the diffused blue light, while allowing the longer wavelength reds and oranges through, distance vision is enhanced
- polarized sunglasses eliminate a lot of glare, because the diffused light coming from the sky is polarized. This again improves the ability to see distant objects

However we must recognise that cutting down the amount of light entering the eye degrades our distance vision. Polarized glasses cut out 50% of the light, and if the glasses have a dark tint, they may cut the light by a further 50% or even more. If only one quarter as much light reaches the eye, the automatic exposure mechanism doubles the pupil size to let more light in. This reduces the depth of focus, making it much more critical that the eye has at rest focus on infinity. It also increases the degrading effects of astigmatism.

Sunglasses are therefore a compromise, and the main recommendation is that you should try to get ones that are not tinted dark. A reddish or orange tint is fine, but only to filter out the blue end of the spectrum, not to make the lens dark.

Prescription sunglasses are preferred rather than clip ons or overglasses, since the more layers you have in front of the eyes, the more likelihood of dust or smears.

pause to take about a quarter of a second, and each pause will see the detail over about 5 degrees of arc.

While it is carrying out all these image processing tasks, the brain is also doing many other things. One important one which needs practice is to develop a mental 3D picture of the sky around you, with plotted positions of where all the other objects you saw in the last few scans are, and which way they are moving. If you cannot see an object on this scan which was there last time, then that object might be moving straight towards you, so that movement relative to the background is not detected. Look particularly hard to find that object!!!

The Auto Focus

Muscles within the eyeball can change the shape of the lens. When these muscles are relaxed, the lens will focus on more distant objects (but see below about long and short sightedness). Tensing the muscles allows focus on closer things. (After the age of around 50 years, the lens becomes stiff, so that ability to adjust the focal length is reduced. This is called presbyopia and should not be confused with long sightedness)

The brain sends signals to these focusing muscles based on the sharpness of the edges of objects in the foveal section of the field of vision. The muscles are adjusted to achieve the sharpest image possible for the thing we want to look at.

While we are on the ground, and looking at features on the ground there will always be objects within the field of vision for the brain to detect and for the autofocus mechanism to operate. However if we look at something without any features, such as a blank wall or the blue sky, there is nothing in the picture to use. In these circumstances, the muscles of the eye relax, and the lens of the eye assumes its at rest focus position. Relaxation occurs within a fraction of a second. For pilots dependent on seeing obstacles in the sky, it is essential that the eye remains in focus for long distance when it is at rest.

Long and Short Sightedness

Nature being variable as it is, the at rest focal length of the population varies, from very shortsighted (myopic) persons at one extreme, where the image is in front of the retina, to extreme longsightedness (hypertrophic), where to image forms behind the retina. Only about 10% of the population have the desirable condition that the image forms focused on the retina when the focusing muscles are relaxed.

Those who are shortsighted cannot make their eyes focus on the distance, since the muscles of the eye can only move the image further away from the retina. The more severe shortsighted will probably have already been to an optometrist, and will have corrective glasses.

There are however many persons with mild myopia who are quite unaware that their distance vision is not as good as it should be. They cope quite well with normal tasks such as driving a car, and believe that their vision is normal.

Each eye has a rather large blind spot because there are no light receptors in the area where the optic nerve joins the eyeball. For the right eye, the blind spot is about 15 degrees to the right of the straight ahead point, and for the left eye it is left of the straight ahead point.

Auto Exposure

The eye has a diaphragm at the front called the iris, which can adjust the size of the aperture (pupil) so that the amount of light getting to the retina is optimised. This happens automatically, with the pupil adjusting from about 2 mm in very bright light to about 8 mm in its fully opened state.

The size of the pupil has an important side effect for focusing. When there is a small aperture such as happens when the light is very bright, the "depth of field" or the range of distance within which focus is acceptable increases. You get much sharper images in bright light than you do when the light is dull and the pupil opens. Furthermore, any defects in the lens such as astigmatism will be less significant when the pupil is small. (Astigmatism means that the lens of the eye has a different focal length in the vertical plane compared to the horizontal plane or sometimes at an angle)

The brain as an image processor

What we perceive when we lookout is not what the eyes see. The information from our eyes is processed by a powerful computer with an image processing program far more powerful than the best programs owned by the CIA for looking at spy photographs. The brain:-

- integrates the images received from each eye into one perceived image
- if it gets only information from one eye, fills in detail in the blind spots based on the most likely features from what it can see
- adds colour to the peripheral field so that images are not perceived as black and white
- does the best it can to sharpen the images where images are blurred
- sends information to the iris to adjust the aperture.
- sends information back to the eyes auto focusing mechanism to adjust the focus if the image appears blurred.
- detects movement in the field of vision where something is changing relative to the background.
- directs both eyes to point their fovea at the same object

The image processing system uses an enormous amount of computing power, and we must be aware that the image processing operates only while the eye(s) are stationary looking at an object. While the eye moves, the processing is turned off.

This implies that our scanning technique must allow pauses so that the information being collected can be processed. During a scan, you can probably allow for each

Gliding and Vision

By David Wilson

Introduction

Avoidance of mid air collisions in our sport is primarily dependent on pilots using their eyes to see and avoid. The eyes are our most important safety asset, and we owe a duty of responsibility to all other users of the air space to make sure that we can use our eyes as effectively as possible.

This article describes some of the important features of the human eye and makes recommendations about what you – as a pilot – should be doing.

The key recommendations are:-

- Get your eyes tested, and get glasses if your eyes do not focus on infinity when at rest
- Practice a scanning technique which recognises that you only see detail while the eye is directed at a stationary point, and then only in a very small arc of the sky.
- practice making a mental 3D image of the sky around you, and where all the other objects you see will be next time you look for them
- Sunglasses should not have a dark tint.

Understanding the eye

Only a small spot about 1.5 mm diameter on the back of your retina is capable of high resolution, i.e. seeing the fine detail in distant objects. In this area, the light receptors are packed very tightly, with each one connected to the brain by a separate nerve fibre. Provided the eye is focused, this area can spot a glider at a distance of about 8 km. However the fovea must be pointed towards the glider and the field of detailed vision is only about 5 degrees wide.

If you watch someone's eyes while they are reading a book, you will see that the eyes make small jumps from left to right. At each momentary pause, the brain takes in a few words, and then the eye jumps across to another point for a momentary pause while the brain reads the next few words. This is because the fovea is not big enough to absorb an entire line while looking at only one point. Our scanning technique when looking for obstacles in the sky needs to adopt a similar technique, for reasons explained below.

The remainder of the back of your eyeball has light receptors spaced further apart, and with several adjacent receptors connected together to one nerve fibre, particularly out in the peripheral vision area. This part of the field of view cannot see the fine detail, and in general sees only in black and white. However, the brain image processing system is programmed to pick up any movement in that area, and we can then move our eyes so that the fovea points to the region where the movement was detected.