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DOCUMENT TITLE
HUMAN PERFORMANCE AND LIMITATIONS

CHAPTER 11 – VISION

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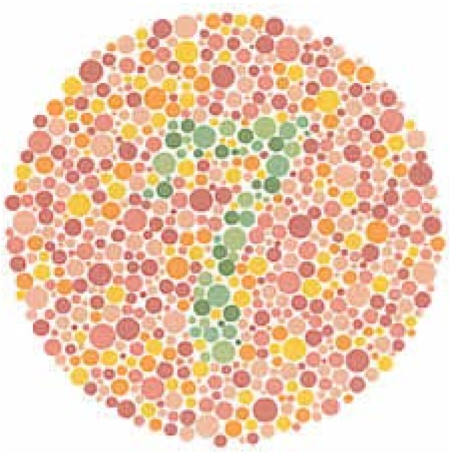
VISION

11.1 Visual System

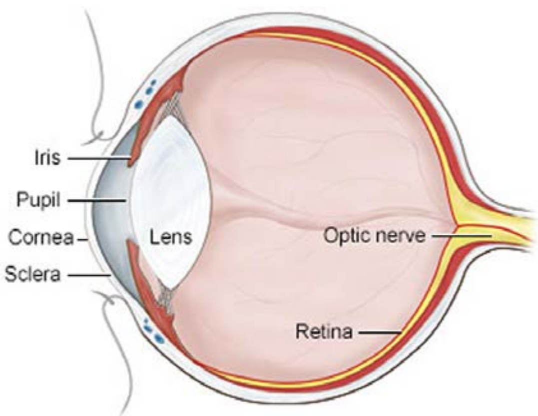
11.1.1 Introduction

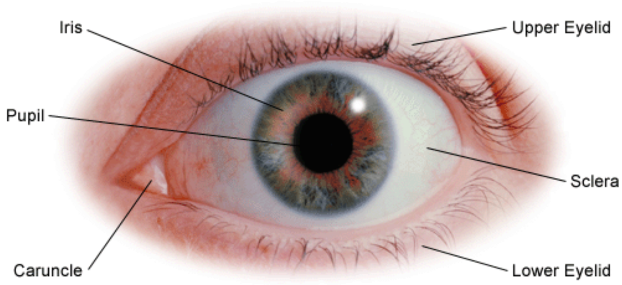
Your eyes are like built-in cameras, they let in light and lenses bend the light to project images on to the "film" at the back of the eyes. The brain then processes the "film" so that you can see images.



The eyes provide instant information about everything around you. They pass information along nerves to the brain to let you see near and distant objects, colours, shapes and movement.

Eyes have a barrage of defences - sturdy skull bones protect them from injury; fat cushions them at the back, eyebrows stop sweat dripping into them, eyelashes catch dirt particles, and blinking washes them with anti-bacterial tear fluid. If dirt does manage to break through, the eyes automatically make extra tear fluid to wash it away.





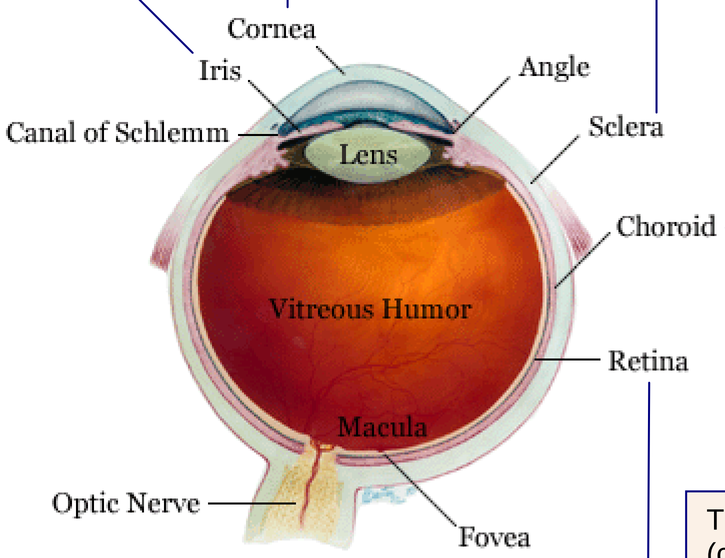
11.1.2 Anatomy

The wall of the eyeball is made up of three layers:

The slightly bulging round window of the eye is the cornea. A thin protective layer called conjunctiva covers it.

The coloured part is the iris and at its centre there is an aperture called the pupil, which lets light into the eye. The iris is able to contract and dilate in reaction to prevailing light intensity.

The tough outer layer (sclera), visible at the front as the 'white' of the eye, provides a protective lining.



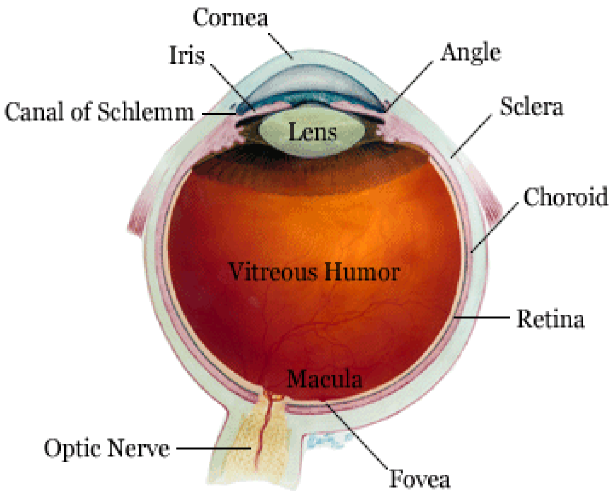
The middle layer (choroids) contains blood vessels to supply oxygen and nutrients.

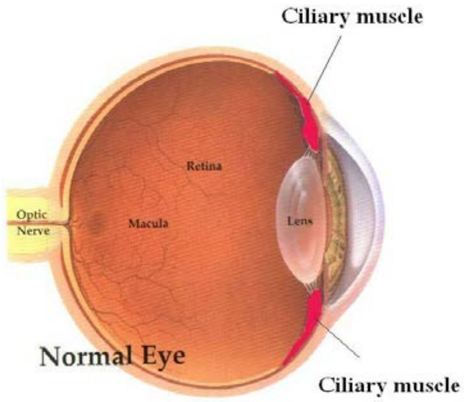
The inner layer (retina) is made of cells, which detect light and colour.

11.1.3 Lens

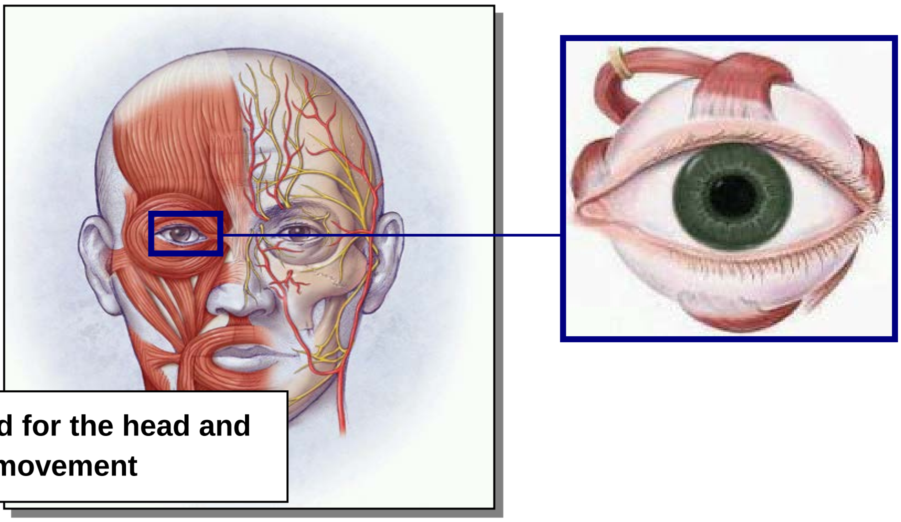
The lens, made up of transparent tissue, lies behind the pupil and is suspended from a circular muscle called **ciliary muscle**. This muscle can change the curvature of the lens by contracting or relaxing thus changing its focal point. This lens adjustment is known as **accommodation**.

Iris controls the size of Pupil by reacting to the different levels of brightness.



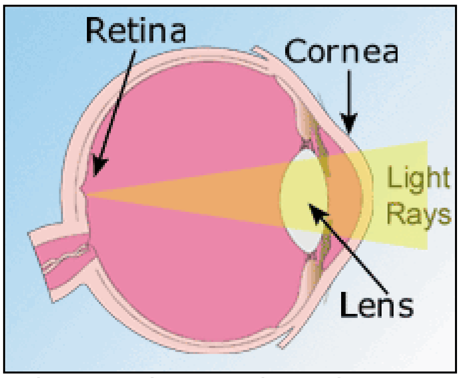


Neck muscles turn the head and other smaller muscles swivel the eyes to provide a panoramic view of the world. Each eye receives a slightly different view and the brain combines both views to provide 3-D vision.



Muscles used for the head and eye movement

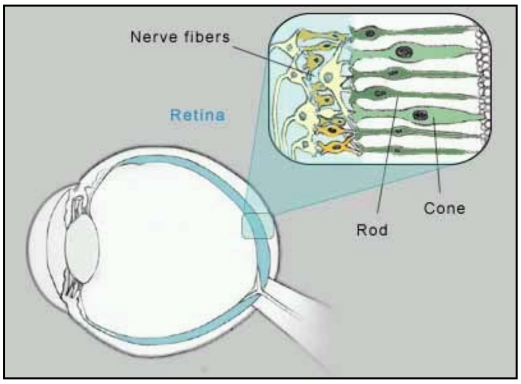
11.1.4 Cornea



When you look at something, light rays enter the eye. The cornea and lens bend the rays so they meet (focus) the light-sensitive surface of the retina at the back of the eye.

The cornea is responsible for 70% of the refraction. The light rays form an upside-down image of what you are looking at. The retina sends electrical signals along the optic nerve to the brain. The brain analyses the signals, turns the image the right way up and tells you what you see.

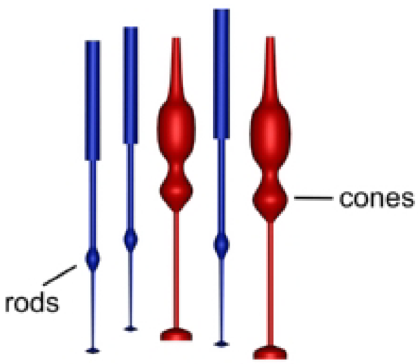
11.1.5 Rods and Cones



The retina has two types of light receptors, called rods and cones. Each eye has about seven million cones and 120 million rods. They detect light rays and change them into electrical signals that the optic nerve carries to the brain.

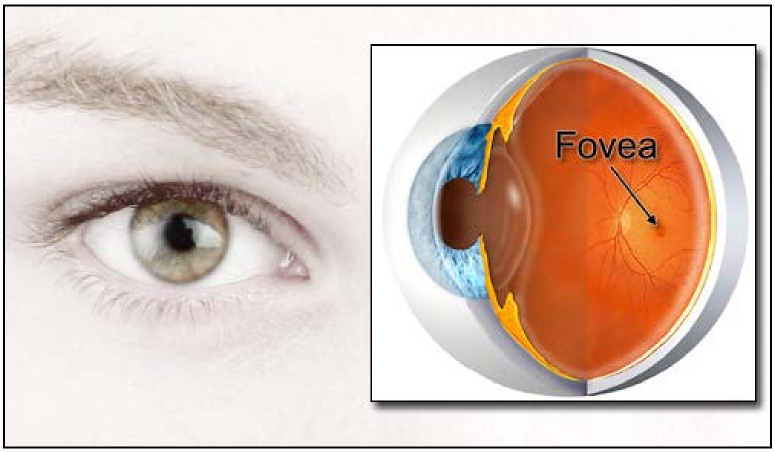
11.1.5.1 Rods (contrast sensitive)

Rods see only in black or white but are very sensitive and work well in the dark or low levels of illumination. Perception of fine detail is also not possible at night (scotopic) vision; therefore **visual acuity** is reduced to approximately 25% of that during day (photopic) vision.



Visual acuity means the capacity of the eye to resolve detail.

There are no rods in the **FOVEA** (the central area of the retina) but the further away we move from the fovea, the higher the concentration of the rods become. The rods are mainly responsible for the perception of movement, thus we can say that our peripheral vision (that what we see outside the central focus area) provides us with a sense of motion and orientation.

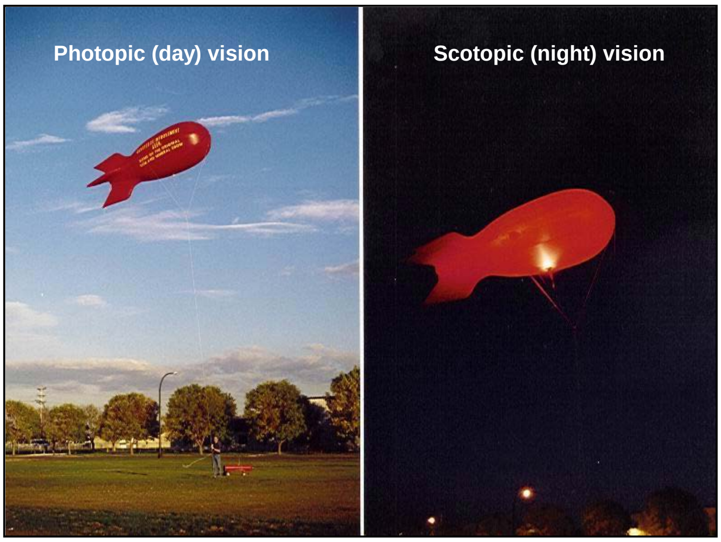


11.1.5.2 Cones (colour sensitive)

Cones detect colours and fine detail but only work well in bright light. At night the illumination on an aircraft's flight deck must be enough to stimulate the cones without being too bright so as to affect the sensitive rods.

Many cones are clustered together in the fovea, opposite the lens in an area called the yellow spot. This is the area of clearest vision. The number of cones decreases progressively as we move away from the fovea, limiting colour vision to the fovea and the small area around it. The cones are also responsible for the ability to determine the shape and definition of an object.

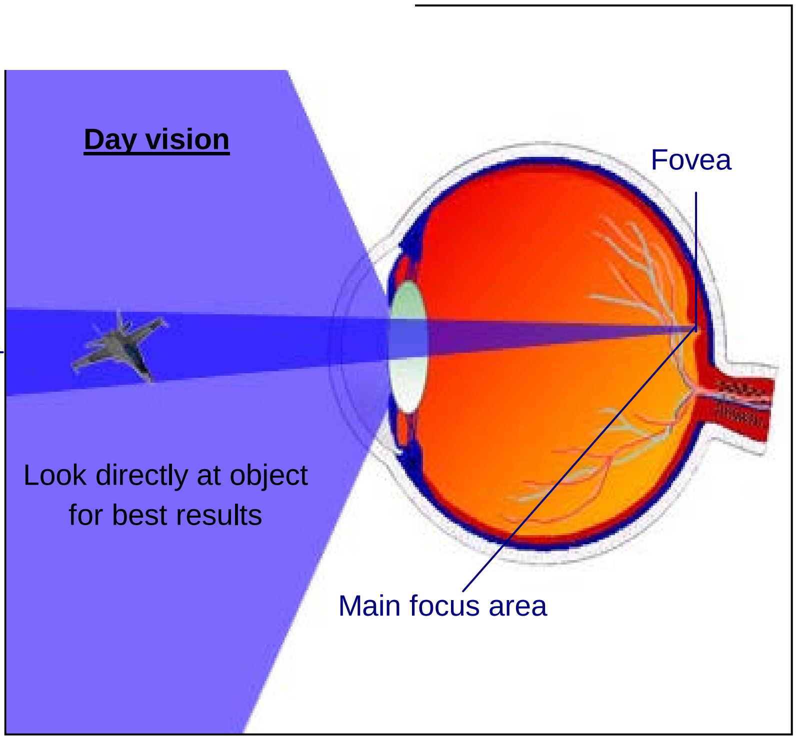
11.1.6 Day and Night Vision



An important distinction between photopic vision and scotopic vision is the differential sensitivity of various parts of the retina due to the distribution of the rods and cones.

In daylight, the eyes see in colour because many images fall directly on the yellow spot. As evening falls, images become grey, not because they have changed colour but because the cones cannot detect colour in the dark and vision relies more on the rods.

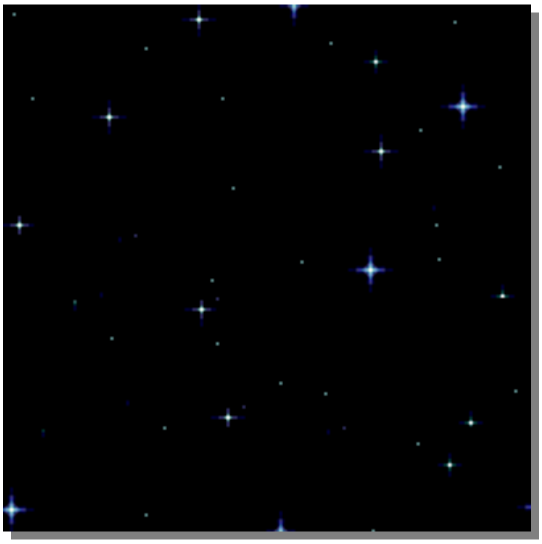
In daylight the best vision is obtained by looking directly at an object with the focus through the lens of the eye falling on the fovea.

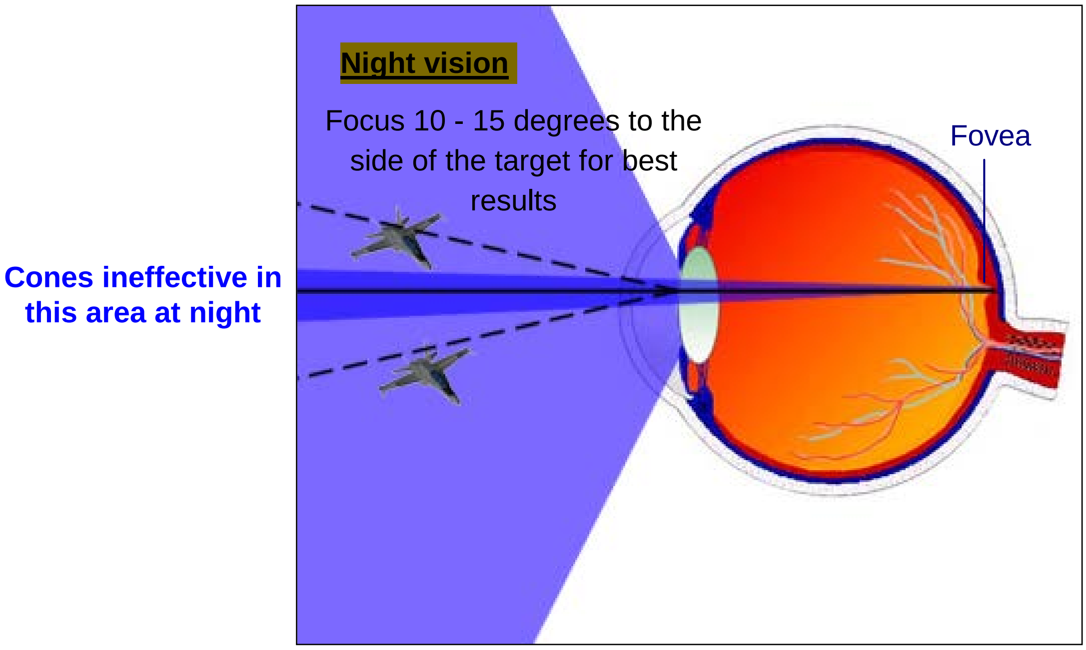


At night the cones in the fovea do not function efficiently and because of the low concentration of rods in this vicinity, the image fades, thus effectively causing a **night blind spot** directly in front of you.

For example, if you stare straight at a bright star at night, it disappears because you are looking with your cones. But if you look slightly to your left or right, your rods will be able to pick up the light of the star.

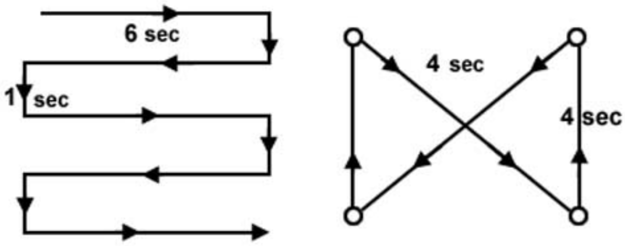
Thus, at night the rods must be exposed to the object to ensure a clear image. This is accomplished by looking 10 to 15 degrees off-centre from the object, as illustrated in the picture.





Scanning in a pre-determined pattern will further improve night vision. If you stare at an object at night, the image begins to fade. Scanning will help to maintain a sharp image. Scanning must be deliberate and slow.

The figures below illustrate two suggested night scanning patterns.

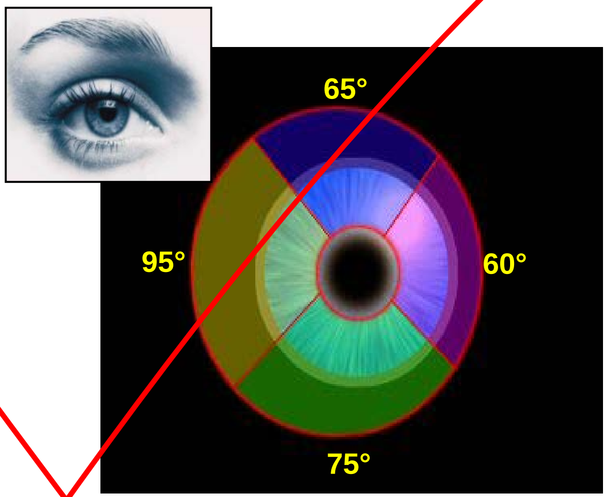


11.1.7 Visual Fields and Visual Acuity

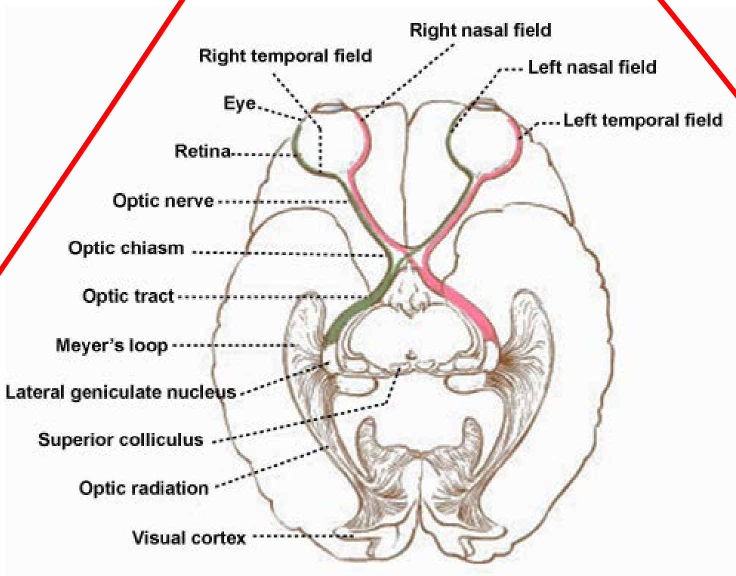
11.1.7.1 Visual Fields

Visual fields are defined as the area or extent of physical space visible to an eye in a given position. When the eye is in the straightforward position, the average fields are:

- 65 degrees upward
- 75 degrees downward
- 60 degrees inwards
- 95 degrees outwards.



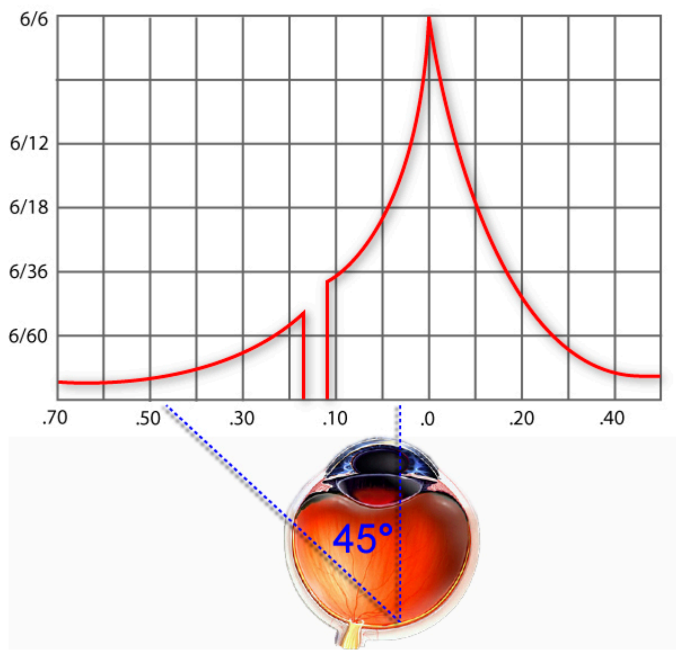
Features such as a prominent eyebrow or nose can physiologically limit this visual field. Furthermore in the brain itself, where the optic nerve crosses the division in the brain (the optic chiasm), the right temporal field (outwards) and the left nasal field (inwards) are perceived as a monocular field (as if viewed through one eye) in the right occipital lobe and the right nasal and left temporal fields as a monocular field in the left occipital lobe.



The eyes automatically refocus when you switch your glance between near and distant objects. If the object is near, muscles in the eye curve the lens, so it bends the light rays more to focus on the retina. If you look at a distant object, the muscles flatten the lens so it bends the rays less and the light hits the right spot.

11.1.7.2 Visual Acuity

The clarity with which we see an object is at a maximum when the light falls on the centre of the retina (fovea). This clarity deteriorates rapidly as the image moves away from the fovea towards the periphery of the retina.



Visual acuity varies with image position on the retina

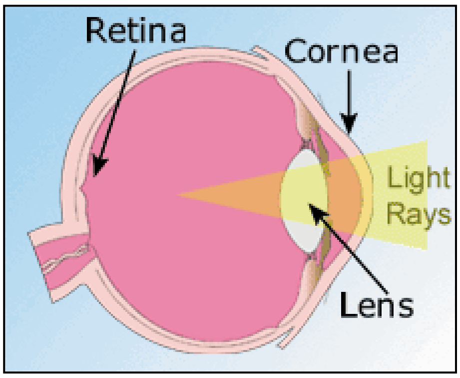
From the diagram it may be seen that the visual acuity for images falling on different parts of the retina varies dramatically. The only position where 6/6, or 20/20 vision can be obtained is the **fovea**. (6/6 vision is our ability to see at 6 m, that which the so-called normal person can see at 6 m. 6/12 means that we need to be 6 m from the object to see it as clearly as the normal person can at 12 m).

If an image falls just 1° from the fovea, the best possible visual acuity is 6/10, if 5° from the fovea, 6/30. As can be seen, visual acuity drops off rapidly as the image moves away from the centre of the retina. **Therefore, for the best visual clarity, we need to be looking directly at the object**. This is why careful and accurate scanning the sky is essential.

11.1.8 Visual Defects

For perfect vision, light rays must focus directly on the retina. Focusing in front or behind it blurs vision. If this occurs, spectacles or contact lenses help the eye to focus rays on the right spot.

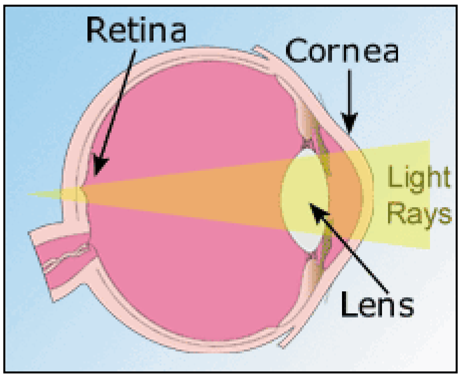
11.1.8.1 Short sight (Myopia)



In myopia, the person sees near objects clearly, but not distant objects.

If the eyeball is to long or the lens is too weak, short sightedness occurs. Vision is unclear as light rays fall short of the retina. Spectacles or contact lenses with concave-shaped (diverging) lenses bend light outwards to focus on the retina.

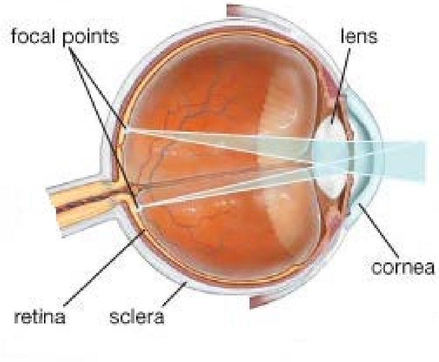
11.1.8.2 Long Sight (Hypermetropia)



In hypermetropia, the person sees distant objects clearly, but not near objects

If the eyeball is too short or the lens is too powerful, long sight occurs. Light rays travel too far to focus on the retina. Spectacles or contact lenses with convex (converging) lenses bend rays inward so they meet together sooner to focus on the retina.

11.1.8.3 Astigmatism



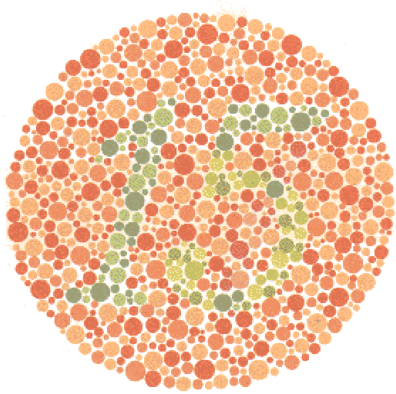
This is an optical effect caused by unevenness of the curvature of the cornea and to a lesser extent, the lens. This error can be corrected by the use of various lens shapes in glasses or contact lenses.

11.1.8.4 Presbyopia (age changes)

As people age, the lens becomes less elastic and ciliary muscles get weaker, so it becomes increasingly more difficult to switch the gaze quickly from close to distant objects.

In most people over the age of 40, the ability to focus on close objects (for example, when reading) deteriorates. This is due to changes in the lens that make it less pliable and therefore reduces the process of accommodation. Where near vision correction is the only correction required, pilots must only use spectacles with correction in the lower visual field, because of the requirement to frequently change to distant vision. 'Look-over', or bi-focal lenses (with an upper section having no optical correction) will achieve this. Where correction for both near and distant vision is required, bifocal lenses are necessary. Variable focus lenses are not generally recommended for pilots.

11.1.8.5 Colour Vision



The International Civil Safety Organisation (ICAO) sets the standards for colour vision. These standards require that he applicant shall be tested by the use of pseudoisochromatic plates (the Ishihara test, of which we are all familiar), or an alternative test that assesses whether candidates "are able to readily distinguish the colours used in air navigation and correctly identify aviation coloured lights."

Normal colour vision should read the number **15**.
Red-Green deficiencies should read the number 17.
Total colour blindness should not be able to read any numeral.

Significant colour vision problems can preclude a pilot from flying at night or from holding a commercial licence, but in some milder cases, a dispensation may be obtained.

In the case of ATPL holders, they must be able to distinguish between red and white lights as this is a critical requirement in interpreting PAPI or T-VASIS approach lights. Special tests are available that may allow a mildly colour-defective pilot to fly.

Total colour blindness is quite rare, but between 5% and 10% of males have difficulty in distinguishing between red and green, or red, green and white lights, and these are the critical colours for aviation. **It is known that smoking and alcohol also have an adverse effect on colour vision.**

11.1.9 Vision Correction

11.1.9.1 Contact Lenses

These are often used in preference to traditional spectacles and have certain advantages, in that they provide better peripheral vision and are not subject to misting. However, for the pilot there are certain associated problems of significance.

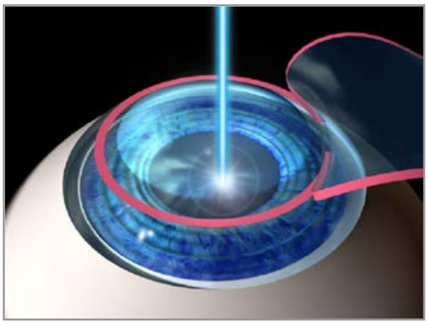
The cornea, not having its own blood supply, obtains oxygen from the ambient air. Contact lenses can reduce absorption of oxygen and may cause corneal hypoxia and corneal damage. Dehydration in the eye can also occur as a result of low humidity in the cockpit, further damaging the cornea. Wearers of spectacles or contact lenses must carry a spare pair of spectacles during flight operations.

Cabin decompression may result in bubble formation and occasionally a contact lens may be dislodged by carelessly rubbing the eyes, an accidental knock or by increased 'g' forces.

Before a pilot can be approved to wear contact lenses he must provide a detailed Ophthalmologist's report, which confirms that the pilot has successfully worn the lenses for 8 hours a day for over one month, however he/she must still carry a pair of ordinary spectacles.

Bifocal contact lenses are unsuitable for use in flying, any near vision correction must be by look-over spectacles and a suitable pair of bifocal spectacles must be carried.

11.1.9.2 Laser Surgery like Radial Keratotomy



This is a surgical procedure on the eye through which certain refractive errors, particularly myopia, can be corrected.

A laser scalpel is used to make shallow incisions into the cornea, which allows the fluid pressure of the eye to push the cornea outwards thereby changing its radius of curvature and hence its refractive properties.

Minimum grounding by CASA after LASIK with a laser keratome is 2 weeks. Other procedures may require a longer grounding period than 4-6 weeks.

The potential effect of treatment on aviation:

- Loss of best corrected visual acuity
- Fluctuation in vision at different times of the day
- Glare, ‘halo’, or ‘starburst’ effects due to corneal haze
- Loss of contrast sensitivity
- Under or over correction.

11.1.10 Depth Perception

Let us now examine a critical factor in the aviation environment, namely that of depth perception (also known in medical terms as Stereopsis).

Due to the disparity between the two eyes, each eye views an object from a slightly different angle resulting in two different images of the same object. These images are then fused in the brain to give us 3-D. This image is assimilated with previous experience and knowledge and allows us to judge the distance to that object. Various factors play a role in the method we use to judge distance or "perceive depth":

11.1.10.1 Binocular cues

There are two binocular cues for depth perception:

- **Accommodative reflex**

As an object is approached, **accommodation** is required to maintain clarity. Through experience the amount of accommodation used provides a clue as to the distance to the object.

Immediately behind the iris is a circular muscle that contains the lens. The curvature and thus the focal length of the lens can be changed by contracting and relaxing this muscle, thus enabling the eye to focus on both far and near objects. This mechanism is known as accommodation.

- **Convergence reflex**

As an object approaches, the eyes must converge to maintain binocular fixation on the target. Through experience, the amount of convergence necessary gives a clue to the distance to the object.

Binocular vision is reliable out to about 15 metres; beyond this we need other techniques.

However, in the flying environment, most of the distances are so great that binocular cues are of little value. In addition, these operate at a subconscious level and are thus not capable of being improved through study and training.

11.1.10.2 Monocular cues

The following are monocular cues to depth perception that the pilot has to use everyday and some of them can be improved through regular practice:

Size of object: Here a known size of an object is compared to its perceived size. The smaller the object is, the further away it is. The eye has difficulty seeing objects the size of which subtends an angle of less than 1 minute of arc. This is equivalent to 1 cm at a distance of 36 m. This assumes perfect viewing conditions – any difficulty in seeing the object will be made worse in poor light or if the object is of poor colour contrast.

In aviation terms, this means that for a light aircraft (with a fuselage cross section of about 1 metre) flying directly towards us, even in perfect conditions, it would be impossible to see it until it was within 2 nautical miles.

We would need to be only a few metres away to see a power line cable – the angle subtended by the wire is well beyond the capacity of the eye to see it in flight. Crop dusters will fly below power lines by a good margin—they cannot see them.

Geometric perspective: Parallel lines tend to converge, i.e. an object has a different apparent shape depending on distance away from the observer.

Overlapping contours: An object is judged to be further away if it is overlapped by another object.

Light and shadows: If an object's shadow is nearer to the observer than the object casting it, then the object is closer than the light source.

Environmental perspective/details: Objects seen in less detail are perceived to be further away than clearly visible objects. If haze is present in the atmosphere, less detail is visible and therefore the distance may be overestimated. If two aircraft are at the same distance away from an observer but their sizes differ, the larger one that can be seen in more detail will normally be judged to be closer.

Terrestrial association: An object's distance can be judged accurately by comparing its size to known features and landmarks.

Motion parallax: Visual perception in high-speed aircraft requires special skills. In order to detect an object at high speed, the following procedure is used:

- Detect an object in the visual field
- Move the eye in the direction of the object and focus
- Identify the object while following its motion closely.

Note: This procedure can take 1.5–2 seconds during which time a large distance may be covered.

11.1.10.3 Empty Field Myopia

Myopia means short-sightedness and Empty Field Myopia occurs when flying at an altitude or in conditions that provides us with a featureless sky.

The ciliary muscles of the lenses relax, which leaves the eyes at a 'resting' focal length that varies widely between individuals from the extremes of between about 40 cm and infinity. However, the average is between **1 and 2 metres**. This means that objects beyond the 'resting' focal length may not be seen, obviously a dangerous situation. Prevention is achieved by actively re-focussing the eyes on a distant object such a wing-tip.

An associated illusion is ~~Mandelbaum effect~~, where the eyes will tend to focus at a distance equivalent to the windscreen centre section, or the windscreen itself, particularly if the windscreen is dirty or scratched.

11.1.11 Adaptation to the Dark

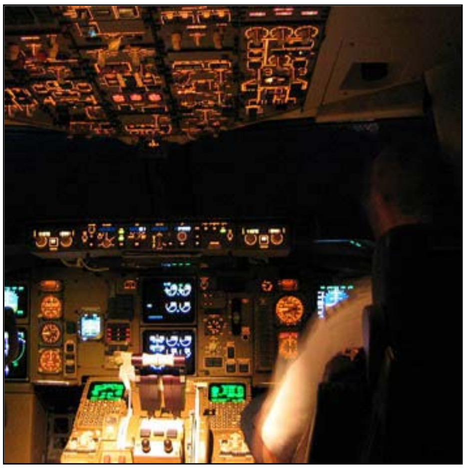
Let's now examine something that is extremely important to an aviator, namely that of dark adaptation. Dark adaptation follows a definite pattern. Initial adaptation (i.e. over the first five minutes) is fairly rapid.

Initially the eye still uses the cones used during the day (remember all colours that we see during poor light conditions are still processed through the cones), but their sensitivity is increased over a small period until it reaches a maximum. If the brain perceives that the images are still not clear enough, the rods start receiving the light inputs automatically.

After the cones have reached maximal sensitivity (five to eight minutes), the rods will take over. Full adaptation is only reached after approximately 30–40 minutes. During this period the sensitivity of the retina increases 10 000 fold.

Take note that dark adaptation time varies according to the initial illumination and the new illumination, as well as with the individual. A sudden bright light, like a lightning strike shown below, will indefinitely destroy night vision adaptation.

The following are methods to improve and maintain night vision:



- Avoid exposure to bright light within 30 minutes before night take-off.
- Keep one eye closed when encountering bright light.
- Use sunglasses in bright light.
- Red cockpit lighting is often utilised in aircraft, but has the disadvantage of distorting colour on maps.
- Keep cockpit lighting as low as possible.

There are several factors that adversely affect night vision:

- Oxygen deficiency (Hypoxia). 4000ft.
- Positive "g"- forces.
- Toxic substances (such as carbon monoxide in the blood).
- Excessive alcohol and tobacco use.
- Fatigue.
- Diet (Vitamin A and C deficiency).

11.1.12 Brightness and Sun Glare

Nature gave us protection from light coming from above us by means of out forehead and eyebrows. But as pilots we are subjected to light reaching our eyes from all angles, particularly upwards when light is reflected off clouds.

Like the Arabs and Eskimos, pilots operate in a high-glare environment. The eye has two ways of adjusting to excessive light, changing the diameter of the pupil (rapid), or chemical change in retina, which will be relatively slow. Despite these changes, it is possible for too much light to reach the retina.

Glare can be caused by high altitude flight, flying just above a layer of cloud or directly into a low sun. The magnitude of the effect depends on how close to the line of sight the source of the glare is. The levels of damaging ultra-violet light also increases with altitude.

The contrast in the levels of brightness outside and inside the cockpit may make it difficult for the pilot to read the instruments or displays. Sensitivity to glare increases with age.

Other effects of brightness and sun glare:

- Visual fatigue
- Stress
- Fixation
- Disrupted accommodation
- Night vision can be affected for up to one week after long exposure to sun-glare, for example, a beach or snow skiing vacation.

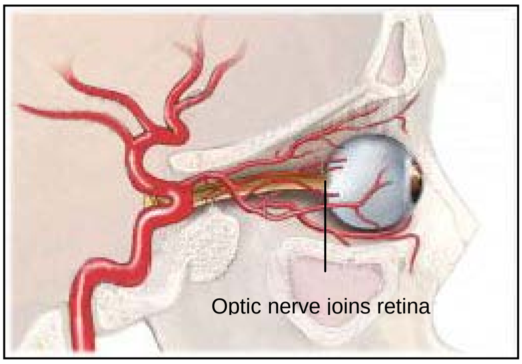
11.1.12.1 Sunglasses

Good quality sunglasses are a necessary requirement in the cockpit. Our eyes are our most important asset. Sunglasses should:

- **Transmit** (i.e. allow through) **10–15% of the light.**
- **Filter out damaging ultra-violet light.**
- **Not be polarised** because they may produce some areas on the windshield with a loss of vision. Looking out through polarised lenses and tinted windscreen at the same time can reduce the retinal image size of traffic.
- Be impact resistant, for safety and durability.
- Have thin metal frames so peripheral vision is not obscured.
- Not be worn in decreased light.
- Have the lens specifications acceptable to the various aviation regulatory authorities. Good quality glasses from reputable sellers will usually have this.

11.1.13 Collision Avoidance

11.1.13.1 Blind Spots



At the point where the optic nerve joins the retina, the eye has a blind spot. It is useless for vision because it cannot detect light, as this area contains no rods or cones. This blind spot is situated approximately 15° outside of the line of sight of the eye.

Normally, you don't notice the blind spot, because one eye makes up for what the other doesn't see.

You can confirm this for yourself by means of this very simple exercise:

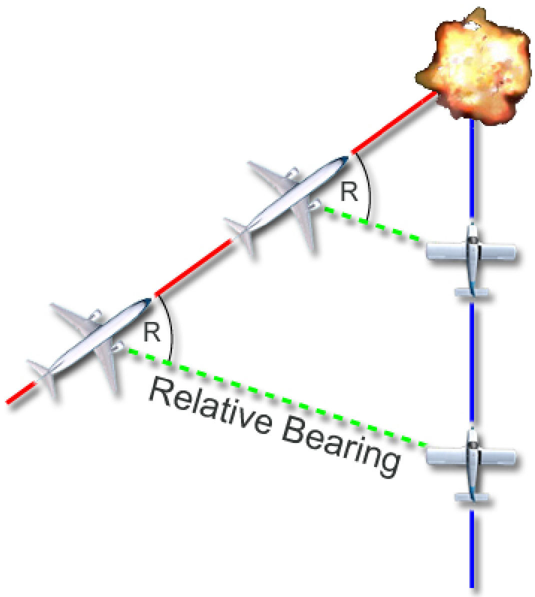
Hold this page at arms' length. Close your right eye and stare at the white spot with your left. Slowly bring the page closer - the white cross vanishes from the corner of your eye when it hits the blind spot.

Remember, this blind spot does not influence normal binocular vision (vision with both eyes versus monocular vision with one eye), as each eye compensates for the blind spot of the other.

11.1.13.2 Constant Relative Bearing

If each aircraft on converging tracks maintains a constant relative bearing to the other, the two will collide.

When considering converging tracks and a constant relative bearing, it is important to note that the two aircraft do **NOT** need to be at the same altitude. A collision can occur if one aircraft is, say, descending. The principle remains; if a constant relative bearing is being maintained in the two (geometric) planes, a collision possibility exists.

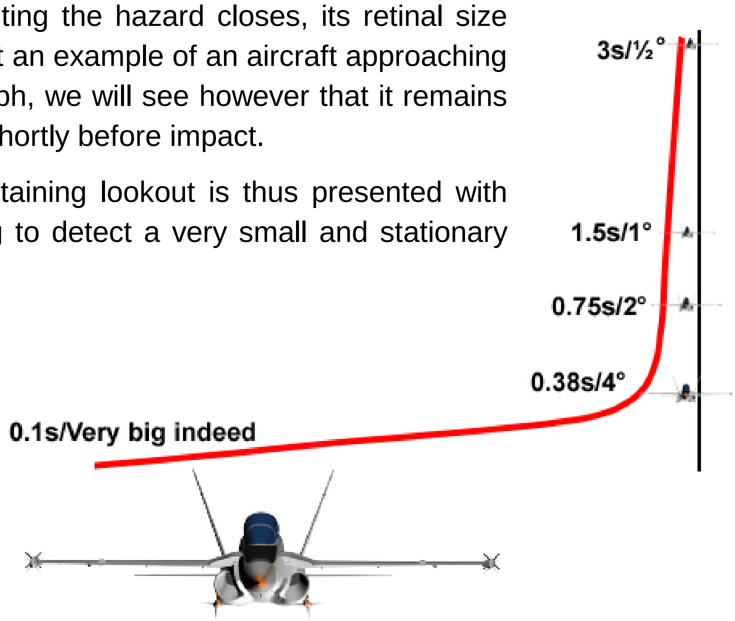


The practical consequence is that all aircraft with which you will **not** collide will track across your windshield.

The one that is on a collision course will however remain stationary and will possess no movement to aid detection!

As the aircraft presenting the hazard closes, its retinal size will increase. If we plot an example of an aircraft approaching at 800 knots on a graph, we will see however that it remains quite small until very shortly before impact.

The pilot that is maintaining lookout is thus presented with the problem of having to detect a very small and stationary target.

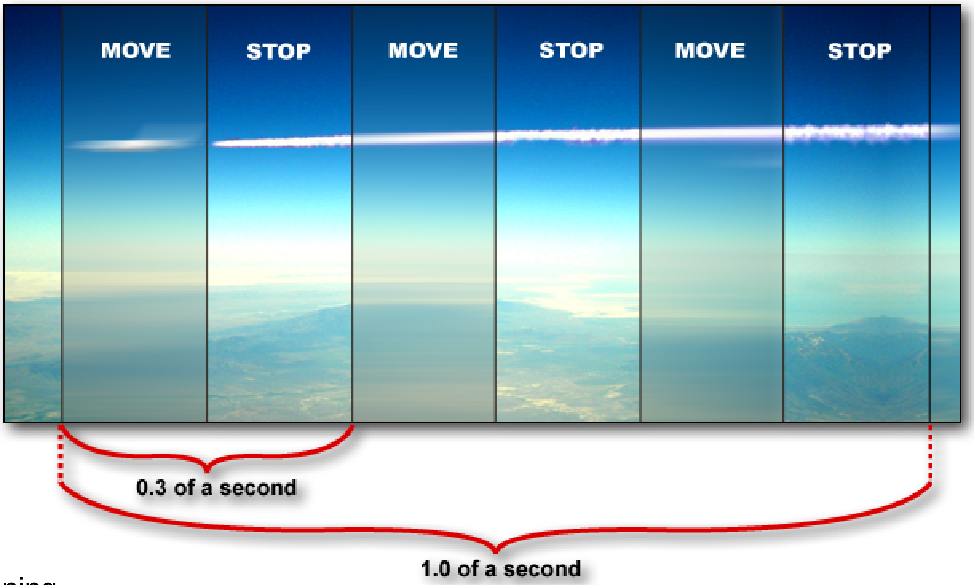


Furthermore, only the central part (fovea) of our eyes have the best vision and if we move our eyes over the horizon in a search pattern, it may seem to us as we scan the horizon in a smooth manner, whereas in actual fact the eyes move in steps or "jerks" and only in the rest periods in between does it feed the image to the brain.

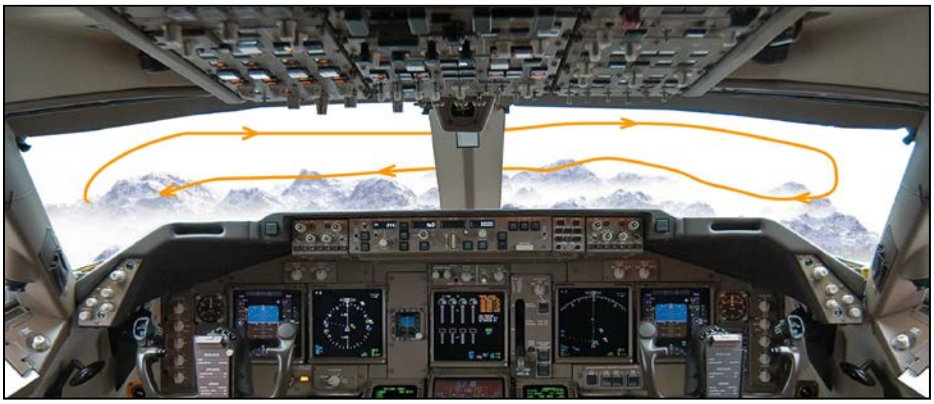
11.1.13.3 Moving-head Scan and Saccade

Like a camera, the eye does not receive clear images when the head is moving. If a person scans the horizon with a continuous sweep of the head, then a lot of the detail will be missed. **The eyes only see clearly when they are not moving**. One move-rest cycle takes 0.3 of a second and is called a **saccade**.

The move-rest cycle should be followed by a period when that sector of the sky is carefully scanned for traffic.



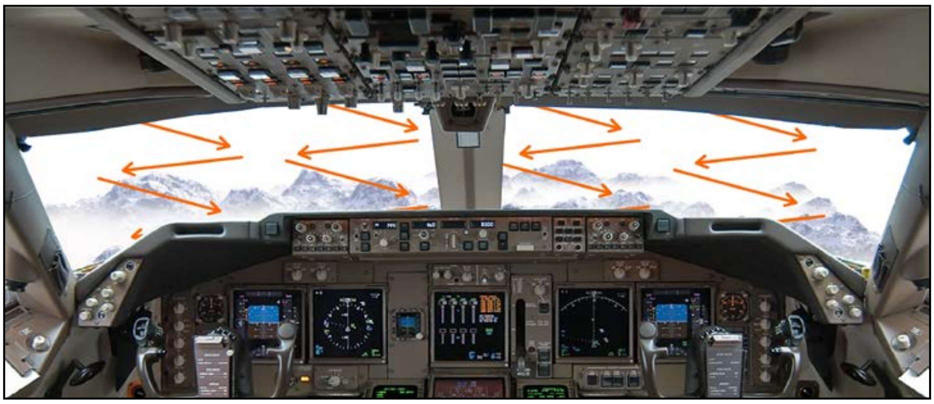
11.1.13.4 Effective Scanning



11.1.13.5 Scan Patterns

Your best defence against in-flight collisions is an efficient scan pattern. The basic scan that has proved best for most pilots is called the **'block' system**. This type of scan is based on the theory that traffic detection can be made only through a series of eye fixations at different points in space. Each of these fixes becomes the focal point of your field of vision (**a block 10^{O}-20^{O} wide**). By focusing every 10^{O} to 20^{O} and allowing 1 to 2 seconds you should be able to detect any contrasting, or moving object in each block.

This gives you 9 to 12 blocks in your scan area, each requiring a minimum of one to two seconds for accommodation and detection.



In flight, we often do not have the luxury of 24 seconds to carry out a full scan, so this system must be applied in a practical and common-sense manner. It will be necessary to set priorities to the areas of sky scanned, to complete the desired scan in the time available. For example, if the aircraft is planning to turn to the left, the sector of the sky to the left should receive priority in the time available for the scan.

11.1.13.6 The Time-sharing Plan

External scanning is just part of the pilot's total eyeball job. To achieve maximum efficiency in flight, one has to establish a good instrument panel scan as well, and learn to give each its proper share of time. The amount of time one spends looking outside the cockpit in relation to what is spent inside depends, to some extent, on the particular phase of flight being undertaken, workload inside the cockpit and the density of traffic outside. Generally, VFR flight will require the pilot to spend a greater amount of time with his eyes outside the cockpit.

11.1.13.7 Panel Scan

An efficient instrument scan is good practice, even if you limit your flying to VFR conditions, when being able to quickly scan the panel allows you to maximise the time your attention is outside of the aircraft.

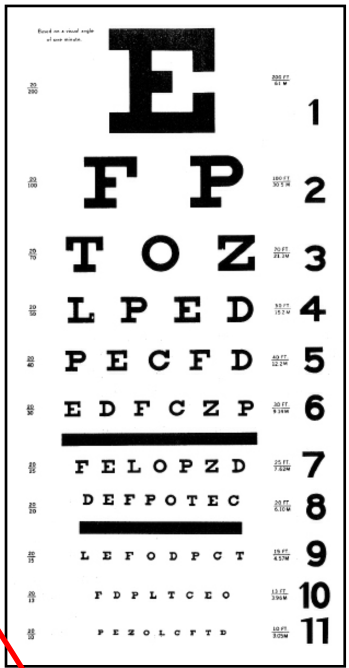
It is universally accepted that the Selective Radial Scan is the best technique for scanning instruments in instrument flight. This topic will be well covered in the instrument phase of training.

Developing an efficient time-sharing plan takes a lot of work and practice, but is an important part of a pilot's skills.

11.2 Maintaining Healthy Eye Sight

11.2.1 Defective Vision

It is obvious why pilots need adequate vision to be able to fly safely. Initial applicants who do not meet the visual standards are prevented from obtaining their licence, yet just as with hearing, there are a number of conditions which can cause a qualified air crew member's vision to deteriorate, including eye injuries, eye disease and ageing (presbyopia).



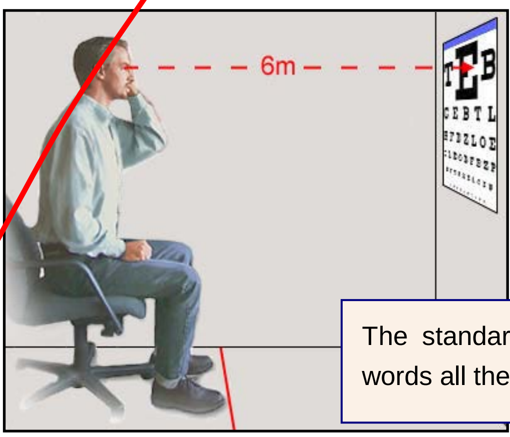
11.2.2 Visual Acuity

Visual acuity is the primary measurement of visual function. Simply put, it is a measure of the eye's ability to discriminate shapes (e.g. the ability to see the difference between a "p", a "f" and a "9").

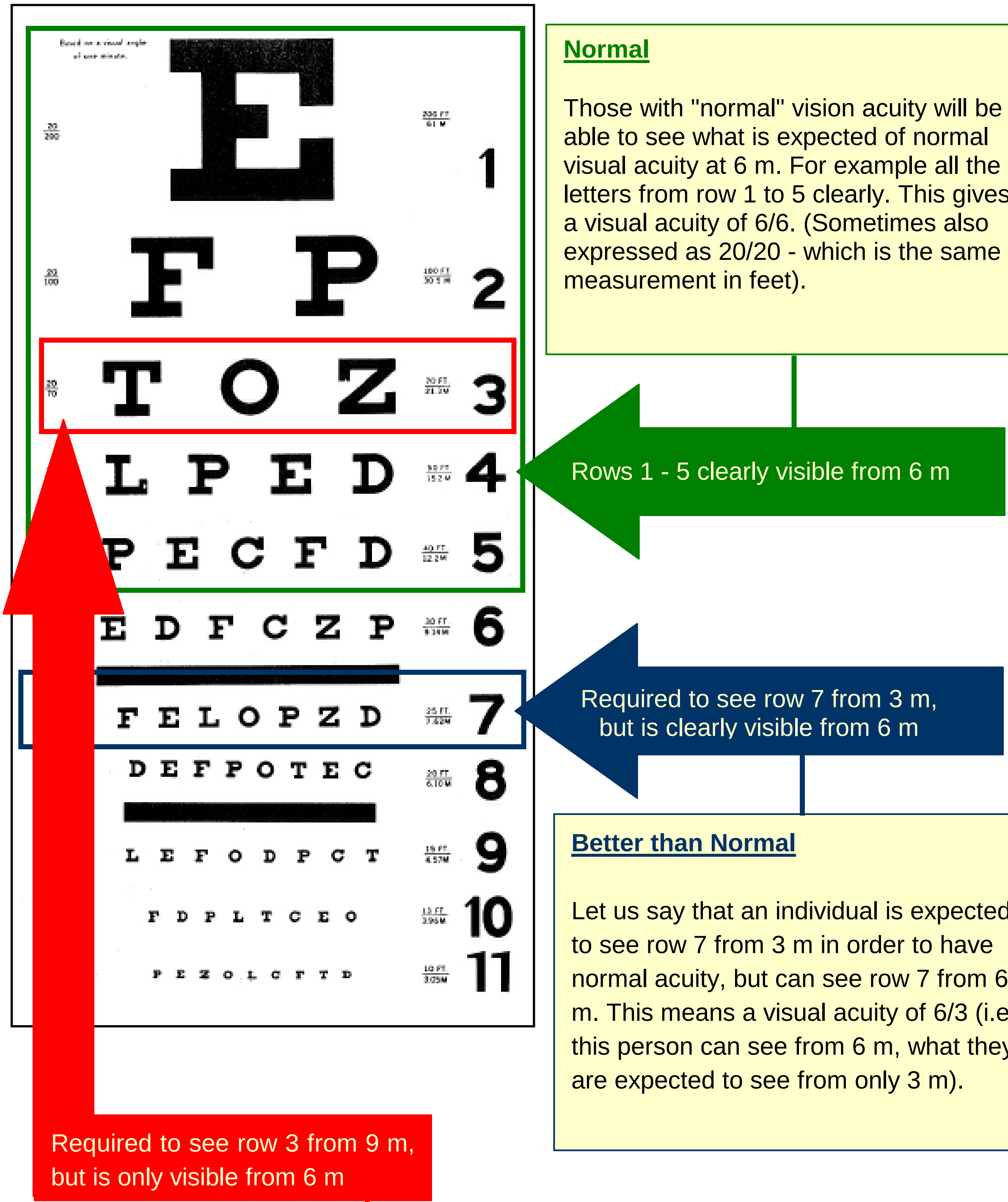
A person with good visual acuity can differentiate between small objects (at a given distance) while a person with poor visual acuity can only differentiate between larger objects at the same distance or alternately, must come closer to the small object to be able to discern it.

11.2.2.1 Measuring Visual Acuity

Visual Acuity is expressed in metric Snellon as follows:



The standard distance used to measure acuity is 6 m. In other words all the candidates are placed 6 m from a wall chart.



Normal

Those with "normal" vision acuity will be able to see what is expected of normal visual acuity at 6 m. For example all the letters from row 1 to 5 clearly. This gives a visual acuity of 6/6. (Sometimes also expressed as 20/20 - which is the same measurement in feet).

Better than Normal

Let us say that an individual is expected to see row 7 from 3 m in order to have normal acuity, but can see row 7 from 6 m. This means a visual acuity of 6/3 (i.e. this person can see from 6 m, what they are expected to see from only 3 m).

Worse than Normal

If an individual can see from 6 m what they should see from say 9 m for normal acuity, they have a visual acuity of 6/9 (i.e. this person can only see from 6 m, what should be seen from 9 m).

11.2.2.2 Visual Acuity Standards

The following visual acuity standards have been specified for various aviation personnel:

Students and Private Pilots

6/12, corrected if necessary, in each eye and **6/9** (with or without correction) with both eyes open.

If the student or private pilot applicant cannot achieve **6/12** (with or without correction) in each eye, the DAME should inquire about the defective eye and record the cause.

In cases of doubt, referral to a CASA Designated Aviation Ophthalmologist or prescribing optician is indicated. These applicants may be acceptable for non-commercial licences; however, their licences will carry endorsements restricting operations to Australia.

By definition, if an applicant achieves no better than **6/12** in the poorer eye, the applicant is considered to be functionally monocular.

Applicants assessed as suitable for licensing with appropriate endorsements are required to have a stable visual condition to which they have adjusted. This provision affects pilots who have poor foveal static visual acuity but whose peripheral vision is normal (in practice, amblyopia). Those who have completely lost an eye or its vision may be assessed as fit after the Aviation Medicine Section’s consideration of such factors as the extent of visual field loss and the duration of the condition.

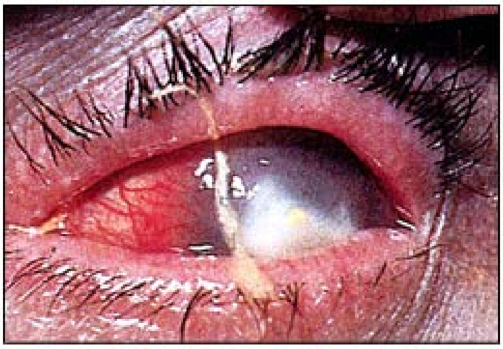
Professional Flight Crew and ATCs

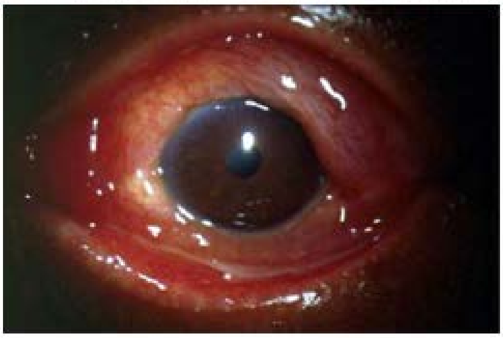
6/9, corrected if necessary, in each eye separately and **6/6** or better when tested with both eyes open.

11.2.2.3 Preventing Loss of Visual Acuity

Poor visual acuity due to refractive errors (e.g. far-sightedness, near-sightedness) can be corrected with glasses, contact lenses or eye surgery (e.g. Laser surgery).

Note: Pilots should note that if they have eye surgery, especially the older Radial Keratotomy, they may not be medically certified in certain circumstances and should find out about medical certification before having the procedure.





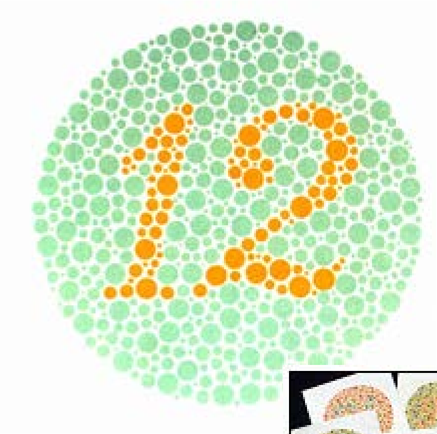
Eye exercises or vitamins cannot improve poor visual acuity, except in the case of night blindness caused by Vitamin A deficiency (xeropthalmia).

Poor visual acuity due to eye injuries or eye diseases can often not be corrected by any means. The important aspects of preserving vision are therefore protection of the eyes against injury (e.g. using protective goggles while working with a grinder) and having eye diseases treated as soon as possible (even if it entails temporary grounding).

Early treatment of eye diseases is essential for aviation personnel

11.2.3 Colour Vision

The ability to discern colour correctly is becoming more and more important in aviation, especially with the use of Electronic Flight Instrumentation Systems (EFIS), where colour is sometimes used to indicate status (e.g. normal, caution or warning) of aircraft systems or conditions. Colour vision is also necessary for the use of optical approach path systems, map reading and sometimes for ATC signalling.



An applicant who fails to meet the colour perception standard (i.e. who fails both the Ishihara Plate Test and the Farnsworth Lantern, but who meets all other standards) is eligible for issue of an operationally restricted student pilot, private pilot or commercial pilot licence. The holder of such a licence is given a dispensation to operate at night in a suitably radio-equipped aircraft. This dispensation applies to Australian airspace only.

Class 1 and class 2 applicants who are unable to pass either the Ishihara Plate Test or Farnsworth Lantern Test may be further assessed by means of Practical Signal Light Test. Details are available from Aviation Medicine Section.

Colour vision defects are usually (but not always) inherited, usually (but not always) occur in males and are usually not treatable in any way. The causes, classification and implications for medical certification of each type is a highly technical and specialised field, and will not be detailed in the scope of this lesson.

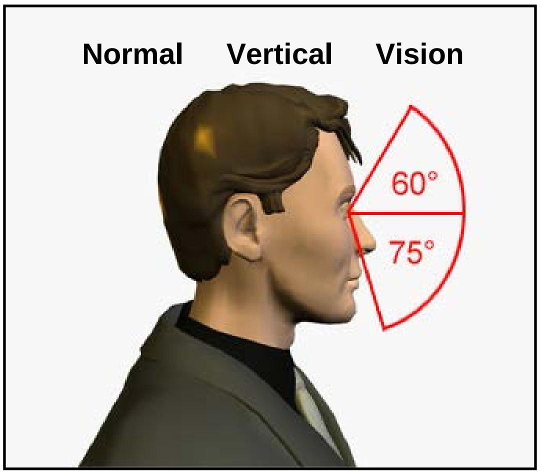
11.2.4 Visual Fields

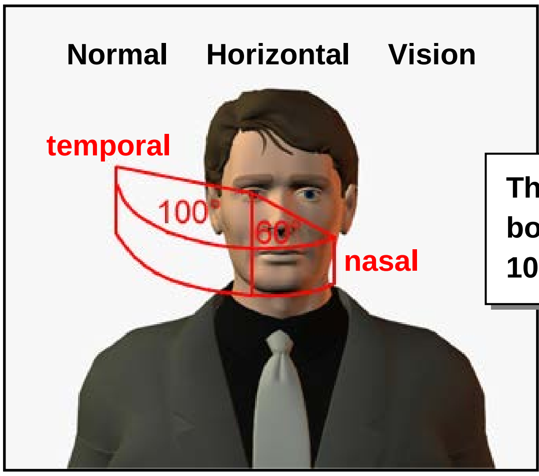
It is important that a pilot's vision has no blind spots (even a large aircraft can fall within a very small blind spot until just before impact).

While correct scanning can often correct for small visual field defects, normal visual fields are required for all classes of medical. Eye injuries or eye diseases like glaucoma usually cause visual field defects, which is eminently treatable, if diagnosed early.

11.2.4.1 Vertical and Horizontal Fields of Vision

Most can see a 135° field - 60° up and 75° down.





The normal field varies according to bone structure, but normally extends 100° temporal and 60° nasal.

11.2.5 Monocularity

Monocular pilots may be divided into two categories:

- **The monocular condition:** the situation in which an applicant has only one functioning eye.
- **The functionally monocular condition:** the situation in which an applicant has two eyes, but the visual acuity of one cannot be corrected to 6/9 or better.

Provided the visual acuity requirements can be met in the functioning eye, with or without correction, a waiver is granted for Class 2 certification, limited to Australian airspace, for both the monocular condition and for functionally monocular pilots.

Likely conditions on an applicant's medical certificate are:

- Not valid for mustering or agricultural flying
- Valid in Australian airspace only
- Special conditions apply.

Functionally monocular pilots who can meet the visual acuity standard with the remaining eye may obtain Class 1 certification. These applicants are required to show that flight safety is not jeopardised by the reduced visual acuity or absence of the other eye. Only the aviation medicine section can issue this waiver. Likely conditions on the resulting medical certificates are as set out above for Class 2 medical certificates.