

Understanding vision part 1: structure and mechanics

Julie Swann is an Independent Occupational Therapist

Abstract

Our vision enables us to gain considerable information about our environment. Most people with a visual impairment have a substantial reduction of vision, but are not totally blind. This article describes the visual system and some of the causes of visual problems. It also outlines the vital role of healthcare assistants and assistant practitioners in the early detection of visual problems.

Key words

■ Sight ■ Impairments ■ Blindness

The visual system enables people to make sense of their environment by interpreting information received through the eyes. This is combined with information from other senses, such as hearing and touch, to help people form instant impressions and to decide whether or not to react to a situation.

The visual system carries out several functions:

- Visual acuity: the ability to see fine details in objects, including small text
- Visual field: the amount of the surrounding area that a person can see in detail
- Colour perception: the ability to perceive all of the different colours of the spectrum, and to be able to distinguish between them
- Contrast sensitivity: the ability to distinguish between different levels of brightness
- Depth perception: detects how near or far an object is, including the distances between objects. It is also used to guide the bodily movements towards, or away from, objects that are seen
- Visual adaptation: enables adjustments in vision when moving from dark to light or light to dark.

Table 1. Muscles of the eye

Muscle	Main function
Medial rectus	Moves eye inwards
Lateral rectus	Moves eye outwards
Superior rectus	Raises eye
Inferior rectus	Lowers eye
Superior and inferior oblique	Rotates eye

Adapted from <http://tinyurl.com/m89zds>

All of these functions can be impaired owing to injury, illness and ageing.

Structure of the eye

The eyes are sited in an optimum position to permit a good field of vision. They are two small tough balls that lie within the orbital cavities (two bony sockets in the skull) (*Figure 1*).

Muscles (*Table 1*) move the eyes within their sockets. The neck and trunk muscles move the head and body, thus increasing the field of vision. Therefore, orthopaedic and neurological problems that restrict neck movement can impact on the range of visual field.

The eyes are protected and shielded by eyelids and eyelashes. The outer layer of the eye, the conjunctiva, is a thin transparent membrane that lines the eye and eyelid and protects the eye from airborne particles.

Tears are produced by the lachrymal gland. Their function is to lubricate and cleanse the conjunctiva. Aqueous humour is a fluid, formed in the ciliary body that fills the front of the eye, protecting the lens and nourishing the cornea.

How we see

When our eyes are open they receive a constant stream of images from the diverse surfaces of objects. The reflected light is transferred through the cornea to many structures before images reach the optical cortex of the brain. The ciliary muscle automatically changes the shape of the lens to improve clarity of vision and to allow focusing on items at various distances. When light enters through the watery aqueous humour, and pupil to the lens; the iris (coloured part) dilates and contracts automatically to adjust the amount of light that is passed through the lens to the retina.

Vitreous humour fills the centre of the eye and maintains the eye's shape; it also allows light to pass through and form a clear image on the retina (the light-sensing) structure of the eye.

The retina contains two types of light sensitive cells:

- Rods that perceive low light but are not colour sensitive (100 million cells).
 - Cones that identify colour and detail (7 million cells).
- The macula is a small area at the rear of the retina that is full of rods and cones. This area enables detailed images

to be seen clearly and at night. When light hits the retina, electrical impulses transmit images via the optic nerve. The optic disc (blind spot) has no rods or cones as this is where the optic nerve and blood vessels leave the retina.

The optic nerve travels to the primary visual cortex of the occipital lobe (back of the head). Some impulses travel onto other parts of the brain including areas that control eye movement.

Considerable processing of images therefore takes place between the light hitting the retina and the time the images are interpreted by the brain to enable appropriate responses to be made. Responses can be automatic or purposeful. Our brain chooses which stimuli to take notice of, and which to ignore. For example, two people walking along a path will notice different objects for a multitude of reasons and may respond in different ways.

Normal vision

Snellen (1862) designed a standardized eye chart to measure visual acuity (clarity of vision). The chart has letters of a decreasing size that are assessed at a distance of 20 feet (Figure 2).

The ratio 20/20 is referred to as perfect vision, or 6/6 if using a metric scale (Table 2), hence the term '20/20 vision', which infers perfect vision. The first number in the ratio refers to the distance the patient is to the eye chart; the bottom number refers to the size of the letters or numbers. The higher the second number, the less the patient is able to identify on the chart.

Other eye charts have been developed to test young children and illiterate adults and these use images and shapes, rather than letters.

Blindness

In the UK, the definition of blindness is derived from the National Assistance Act 1948, which says that a person can be certified as blind if they are 'so blind that they cannot do any work for which eyesight is essential'. A person can be registered as partially sighted if their visual acuity is 3/60 or worse or 6/60 if their field of vision is very restricted.

Incidence of visual problems

The Royal National Institute for the Blind (RNIB) (2009) estimates the population of people with significant sight loss in the UK, using the broad definition, to be around 2 million. There are an estimated 25 000 children with sight problems in the UK (RNIB, 2009). The RNIB (2009) state:

'Every day in the UK another 100 people start to lose their sight. Sight problems are more common than we think.'

The World Health Organization (WHO) (2007) note that around 75% of cases of blindness are treatable or preventable. *VISION 2020: The Right to Sight* is a global

Figure 1. The eye

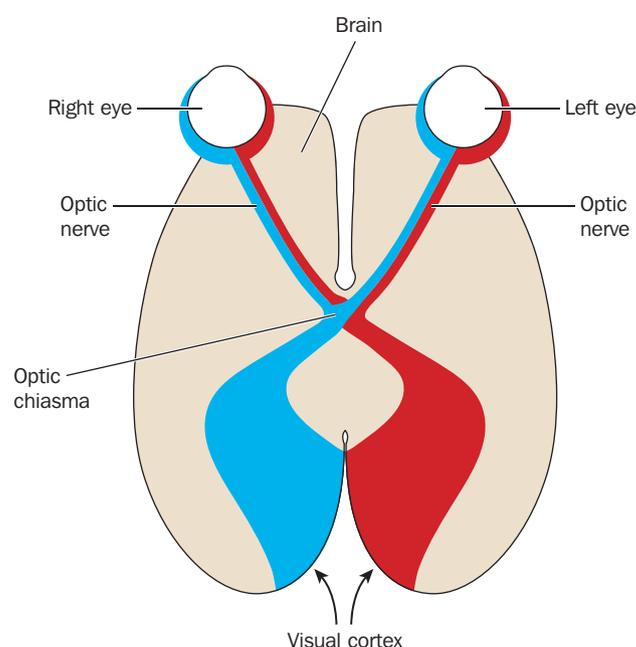
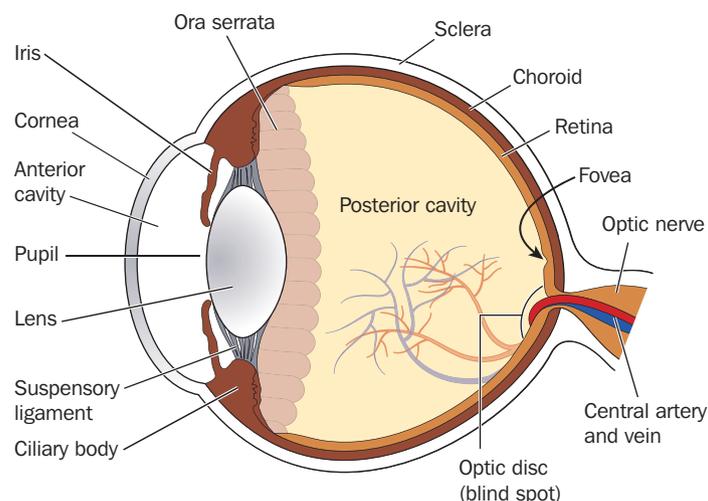
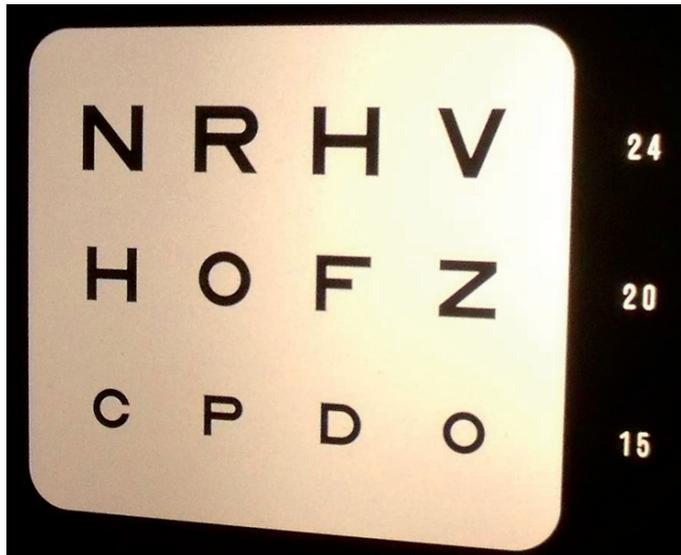


Table 2. Eye chart - conversion from feet (Snellen) to Metric a scale

Snellen (feet)	Metric
20/10	6/3
20/15	6/4.5
20/20	6/6
20/25	6/7.5
20/30	6/9
20/40	6/12
20/50	6/15
20/100	6/30
20/200	6/60

Adapted from: Strouse (undated)

Figure 2. An adult Snellen eye chart



initiative to eliminate avoidable blindness, co-ordinated jointly by WHO and the International Agency for the Prevention of Blindness (IAPB).

Role of healthcare assistants

There are many ways that healthcare staff can assist to improve the quality of services that are provided to people with visual problems. The RNIB's UK Vision Strategy (RNIB, 2008) brings together people with sight loss, users of eye-care services, eye health and social care professionals and statutory and voluntary organizations to produce a unified framework for action on all issues relating to vision, across the UK. Healthcare assistants (HCAs) and assistant practitioners (APs) are in an ideal position to be an internal part of this strategy, whose broad objectives are:

- To prevent avoidable blindness
- To improve the quality of services to visually impaired people
- To improve the training available to professionals providing advice and services
- To improve communication between organizations within the VI (visually impaired) sector
- To improve the availability of information to visually impaired people
- To ensure that the voices of the visually impaired are heard when planning services and their opinions sought on key issues affecting their lives
- To raise public awareness of the issues and problems relating to sight loss. (<http://www.vision2020uk.org.uk/>)

Poor vision should not be simply construed as the irreversible process of ageing as there may be an underlying medical problem such as diabetes and early stage glaucoma that may be treatable. RNIB (2009) note that many sight problems are preventable and over 50% of all sight problems in older people in the UK could be corrected by prescribing correct

glasses or lenses or by cataract surgery. HCAs and APs can encourage patients to have regular eye screening, and to report any deterioration of their vision.

Common visual problems

The eye has its own group of disorders that affect ocular structures. Visual impairment can be present at birth or occur at any time owing to a disease or an accident. There are many medical conditions or syndromes that can cause loss of vision such as vitamin A deficiency, brain tumours, strokes, neurological diseases (multiple sclerosis), hereditary diseases, toxins and other infections.

Visual deficits can range from acuity problems, loss of vision in one eye, to loss of visual fields. Healthcare staff may need to explain a loss of visual field or visual attention to a patient's visitors, so that they sit within the range of vision.

Temporary visual problems can occur owing to fatigue, over-exposure to the elements when outdoors, many medications, excessive alcohol or drug abuse. Some common eye conditions are described below.

Cornea and lens

- Myopia (short/near sightedness) and hypermetropia (long /far sightedness) occurs when the lens and cornea are unable to focus properly. Myopia results from elongation of the eyeball or thickening of the lens. This causes focusing of the image in front of the retina. Hypermetropia is when the eyeball is too short or the lens is too thin, causing the image to focus behind the retina. Presbyopia (age-related hypermetropia) is owing to loss of elasticity and thickening of the lens and starts around 40 years of age. These conditions can be corrected by the use of appropriate lenses
- Dry eyes can occur owing to reduction of secretions causing the conjunctiva to become dry
- Cataracts are cloudiness of the lens that prevents light reaching the retina. Causes include natural hardening of the lens owing to ageing or damage to the eye, for example heat or radiation. Cataracts are painless and more common in elderly people, although babies can be born with a cataract. Surgical replacement of the lens can help.

Inner eye

- Glaucoma is a build-up of aqueous humour caused by drainage problems and produces a build-up of pressure within the eye. Damage to the cells of the retina (retinal atrophy) and optic nerve fibres can cause blindness. This can be treated with daily administration of eye drops, or an artificial drainage hole can be created in the eye
- Diabetic retinopathy is owing to blockage of blood vessels; leakage of blood vessels or scarring that can lead to blindness. It is caused by diabetes and is treatable by laser surgery
- Retinal detachment symptoms include floaters, flashes of light across visual field, or a sensation of a shade

Figure 3. An eye examination



or curtain hanging on one side of visual field. Laser surgery can assist

- Macular degeneration is loss of central vision owing to deterioration of the macula (yellow spot on the retina that contains a high concentration of rods and cones). It can be helped with laser surgery.

Many people in developing countries have eye problems that are linked to extreme poverty and poor sanitation. For example:

- Trachoma is triggered by bacteria (*chlamydia trachomatis*) producing repeated conjunctivitis resulting in corneal damage. Discharges from infected eyes attracts flies that then land on other people's skin. People in crowded households or neighbourhoods are particularly vulnerable, but it is treatable with antibiotics
- River blindness is caused by a parasitic worm, *onchocerca volvulus*. The larvae are spread by the black simulium fly, which breeds in the high-oxygen water of fast-flowing rivers. The fly transmits the disease when it bites people. (Swann, 2008)

Investigations

Regular eye checks are essential for all age groups as eye problems can occur in very young children, which will

impact on the acquisition of skills. Any visual problems, excess or under secretion, soreness or rubbing should be reported to clinicians.

Some patients may have problems accessing opticians owing to mobility problems. Some opticians have ground-floor wheelchair-accessible examination rooms or will provide home visits.

Visual assessment includes measurement of visual acuity, colour vision, and visual fields (*Figure 3*). It also includes an examination of the interior of the eye and measurement of eye pressure. If an eye condition is noticed the optician may suggest a referral to an ophthalmologist (physicians who diagnose and treat diseases that affect the eyes).

At an eye clinic, drops are normally put in the eye(s) to dilate the pupil(s) for the purpose of examination and refraction. The eye drops can sting and also will impair the ability to focus for 3–4 hours, hence there is a risk of falling during this time, particularly if the gait is unsteady.

For many years, the only form of assistive devices was single magnifying glasses or single lens glasses. Today, there is a wide array of frames and lenses (*Figure 4*) including single lens, bifocals, variofocals, prism glasses and contact lenses.

Key Points

- Regular eye checks are important.
- Many eye problems can go unnoticed for example: glaucoma and diabetic retinopathy.
- Seventy-five per cent of cases of visual problems are preventable and treatable.

Conclusion

Problems with vision can happen to any age group and can be symptoms of an underlying systemic disease. A reduction of vision is therefore not an irreversible by-product of ageing; there are many medical conditions that need to be investigated, and treatment can prevent irreversible damage to the eye. HCAs and APs should encourage patients to have regular eye tests and to report any changes to clinicians.

There is a wide range of equipment that can be obtained to increase visual acuity. There are many other methods that can enhance vision, including environmental changes and equipment to assist with failing vision. HPCs and APs can inform patients of the help that is available and these aspects will be discussed in the next article. BJHCA

Acknowledgement: The author wishes to thank Malcolm Broad Opticians for allowing Figure 2 and Figure 3 to be taken at their premises.

Royal National Institute for the Blind (2008) *UK Vision Strategy*. <http://tinyurl.com/nzdmmg> (Accessed 16 June 2009)
 Royal National Institute for the Blind (2009) *Statistics - numbers of people with sight problems by age group in the UK*. <http://tinyurl.com/ksew6e>
 Snellen H (1862) Letterproeven tot Bepaling der Gezigsscherpte (PW van der Weijer 1862) cited in Bennett AG Ophthalmic test types. *The British Journal of Physiological Optics* (1965) **22**: 238-71
 Strouse Watt W (undated) *How Visual Acuity Is Measured*. <http://tinyurl.com/1w21> (Accessed 16 June 2009)
 Swann J (2008) Mechanics of vision and common visual impairments. *Nursing & Residential Care* **10**(1): 633-36
 World Health Organisation (2007) *What is VISION 2020?* <http://tinyurl.com/ltevil> (Accessed 16 June 2009)

Figure 4. Some examples of the range of frames available



Useful organizations

British Council for Prevention of Blindness
 59-60 Russell Square
 London, WC1B 4HP
 Tel: 020 7953 3777
<http://www.bcpb.org/contact.html>

RNIB Eye Health Information Service
 105 Judd Street
 London, WC1H 9NE
 Tel: 020 7388 1266
<http://www.rnib.co.uk/>

The Partially Sighted Society
 7-9 Bennetthorpe Doncaster
 South Yorkshire, DN2 6AA
 Tel: 0844 477 4966
 Email: info@partightsight.org.uk

CALL FOR CLINICAL PAPERS

Do you have a research, education or clinical issue you would like to write about?

Share your experience by sending your manuscript to:

The editor | British Journal of Healthcare Assistants
 MA Healthcare Ltd | St Jude's Church | Dulwich Road | London SE24 0PB
 Email: julie.s@markallengroup.com