

Colour vision and its disorders

The neuroretinal cells concerned with processing vision are known as rods and cones, the latter being concerned with colour vision. There are three types of cones:^[1]

- Red cones (74% of cones).
- Blue cones (16%).
- Green cones (10%).

Each type of cone has a different range of light sensitivity. Stimulation of the cones in different combinations enables the perception of colours - eg, the perception of yellow results from a combination of inputs from green and red cones and relatively little input from blue cones. If all three cones are stimulated then white is perceived.

Types of colour vision defect

Colour blindness is the inability to distinguish certain colours. It occurs when one or more of the cone types are absent or present but defective and unable to send correct signals to the brain. If a pigment is deficient, a patient is said to have a protanomaly and, if they are entirely absent, they are said to have protanopia.

- Trichromatic: all three cone pigments are present and colour vision is normal.

- Dichromatic: complete deficiency in one cone pigment but the remaining two are normal. There are three types of dichromatism depending on which one of the three normal pigments is missing:
 - Protanopes are the most common and lack red sensitive receptors.
 - Deuteranopes lack green receptors and tritanopes (rare) lack blue sensitive receptors.
 - Protanopes and deuteranopes cannot distinguish red from green light.
 - Tritanopes cannot distinguish blue from yellow.
- Monochromatic: only one cone pigment. Tends to be associated with reduced visual acuity (usually 6/60), photophobia, nystagmus and sluggish pupil reflex to light.
- Achromatic functioning cones: can only see black, white and shades of grey. Typical complete achromatopsia tends to be associated with reduced visual acuity, photophobia and pendular nystagmus.

How common are colour vision defects? (Epidemiology)

- Most cases of colour blindness are hereditary but are occasionally acquired as a result of eye disease.
- The ability to distinguish colours deteriorates with ageing.
- Prevalence of defects is estimated as between 2-8% of males.^[2]
- The most common hereditary colour vision defect is failure of red-green discrimination (prevalence is 8% in males and 0.5% in females). The gene for red-green colour blindness is X-linked recessive.
- Failure of blue-yellow is rare and is more commonly acquired.
- Monochromatic: relatively rare (incidence of about 1 in 30,000).

Symptoms of colour vision defects (presentation)

- Colours which look different to people with normal colour vision can look the same to people with defective colour vision – eg, grass may appear green with normal colour vision but appear to be the same colour as orange for people with certain colour-defective vision.
 - There is also a marked reduction in the number of separate colours that can be distinguished in the spectrum.
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Investigations

The Ishihara plates are designed to provide a screening assessment of red-green colour vision:^[3]

- The Ishihara plate is a crude test but can be easily used in general practice or casualty.
- It consists of a series of 16 plates with a matrix of dots arranged to show a number.
- It was designed to screen for congenital red and green cone abnormalities and therefore is somewhat limited in use for more complex diagnoses.
- Sit the patient in a well-lit room and ask them to put their reading glasses on. Get them to cover one eye and flick through the plates allowing for about five seconds per plate. Repeat with the other eye.
- The first plate is a test plate that colour-blind patients can see and therefore helps identify malingerers.
- Other causes for not being able to read the numbers easily include poor visual acuity, illiteracy (get them to trace out with their finger on the plate, the figure that they see; there are also picture plates) and severely restricted visual fields. Optic nerve lesions will also affect performance.

Tablet-based testing has been developed for children and smartphone for general use.^{[4] [5]}

Associated diseases

- Colour vision is often affected by optic nerve disease:
 - Colour vision is affected before visual acuity but will not be noticed by the patient until relatively late and usually after visual acuity is affected.
 - For this reason it is very important to test colour vision in a suspected [optic nerve lesion](#) and also in suspected [thyroid eye disease](#).
 - If you do not have an Ishihara plate, get the patient to look at a bright red object (eg, a child's toy) and compare one side with the other.
 - Descriptions of things looking washed out should ring alarm bells.
- Macular disease tends to produce blue-yellow visual defects. The vision may be blurred and there is particularly a straight line distortion.
- Loss of colour vision has been reported in association with [diabetes mellitus](#), [cataracts](#), [glaucoma](#), [macular degeneration](#), [Alzheimer's disease](#), [Parkinson's disease](#), [leukaemia](#) and [sickle cell disease](#).
- Colour vision can also be affected by some medications - eg, tamoxifen.
- Some chemicals may cause loss of colour vision - eg, carbon disulphide, mercury, fertilisers.

Management of colour vision defects

- No treatment can completely correct or prevent inherited colour vision deficiencies.
- Contact lenses can increase colour perception but they are bulky and expensive.^[6]
- Treatments that slow or reverse the course of an eye disease may also improve colour vision.

Complications of colour vision defects

Disorders of colour vision cause difficulty at school and affect the choice of certain jobs and careers that require some degree of colour identification. The list of affected careers includes:

- Certain grades within the armed forces.
- Civil aviation: pilots, engineers, technical and maintenance staff, air traffic controllers.
- Customs and excise officers.
- Railways: drivers, engineers and maintenance staff.
- Fire service officers.
- Hospital laboratory technicians and pharmacists.
- Workers in paint, paper and textile manufacture, photography and fine art reproduction.

Important information

The restriction from being an airline pilot because of defective colour vision is now being contested. For example, Australian airlines do now allow people with colour vision deficiency to be pilots. ^[7]

Colour blindness need not prevent someone from driving because traffic lights can be distinguished by the position of the light.

Further reading

- [Online colour vision tests](#)
- [Colour vision examination: A guide for occupational health providers](#); Health and Safety Executive (HSE) Guidance Note MS7 (Third edition)
- [Aboshiha J, Dubis AM, Carroll J, et al; The cone dysfunction syndromes. Br J Ophthalmol. 2016 Jan;100\(1\):115-21. doi: 10.1136/bjophthalmol-2014-306505. Epub 2015 Mar 13.](#)

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