Types of Eye Movements

The information given here is deliberately non-technical and is based for a general audience. With apologies to eye movement research colleagues for liberties taken in simplification.

In our everyday lives we regularly make various types of eye movements, usually without being aware of them. Such movements occur as a result of the activity of the three pairs of antagonistic muscles that support each eye. There are several ways to record eye movements and more information can be found here.

In looking at paintings, or other two-dimensional scenes, only saccadic eye movements and their associated fixations, in the main, are of research interest. Miniature eye movements also occur, and these overlay the fixations causing many small movements which, to a large extent, can be regarded as 'system noise' (unless the researcher is specifically interested in these movements).

Main types of eye movements:- [this list of links all link to subsequent sections on this page]

Saccade

A saccade is a rapid eye movement (a jump) which is usually conjugate (i.e. both eyes move together in the same direction) and under voluntary control. Broadly speaking the purpose of these movements is to bring images of particular areas of the visual world to fall onto the fovea. Saccades are therefore a major instrument of selective visual attention. It is often convenient (but somewhat inaccurate) to consider both that a saccadic eye movement always occurs in a straight line and also that we do not 'see' during these movements. We can therefore simply consider that we often see the world by means of a series of saccadic jumps from one area to another, interspersed with fixations. Note, however, that these are oversimplifications.

A fixation is when the eye is 'stationary' (but see the miniature eye movements section) between saccades and it is convenient to consider that the area imaged on to the fovea (or very near to the fovea) during a fixation is being visually attended to by the observer. Fixations differ in their length but tend to be about 200-300ms, although much longer fixations can occur. The length of fixations is an important research topic in itself as it relates to the visual information to which the observer is attending as well as to his/her cognitive state. Precisely when a fixation starts and ends is itself a matter of research interest as the recorded fixation length is itself somewhat related to the temporal sampling rate of the eye movement recording technique being used.

Most saccades are less than about 15o in size. When we make a saccadic movement towards a specific object then the saccade can either accurately land on the object or, commonly, either overshoot or undershoot it, so giving rise to a subsequent small corrective saccade to the object. Note that saccadic movements can be curved as well as straight. Saccades are very fast with a peak velocity of about 700osec-1. During a saccadic movement our vision is not completely eliminated but it is considerably reduced (this is known as saccadic suppression). There is a small refractory period between saccades of

about 150ms which limits the number of saccadic movements we can make in a given period of time.

Saccades are preprogrammed (ballistic) movements such that during the previous fixation, not only is information foveally attended to but also the location of the next fixation is determined and a saccade then executed to that location. During a fixation therefore both the current foveal and peripheral information help guide the following saccade and associated fixation location.

Examples: A good example of a sequence of saccades and fixations is reading a book or looking at pictures. In driving we make saccades as we look at; cars ahead of us, road traffic signs, the vehicle instrumentation and the rear view mirror.

Miniature eye movements

When we stare at (i.e. fixate) an object we may think that our eyes are not moving. In fact they are constantly moving, making very small movements which are all generally less than 1o in size. There are various types of miniature eye movements, including; flicks, drifts, irregular movements and high frequency tremors. When we fixate on an object then its image falls on the fovea. The effect of such small movements is to constantly shift this image minutely over the fovea so that the fovea is constantly being stimulated – if this did not happen then the image of the object would fade.

Drifts are slow movements away from a fixation point. Flicks or microsaccades reposition the eye on the target. Predominantly these are corrective movements, correcting for the off-centre foveal position produced by a drift eye movement. Irregular slow movements of the eye also occur. High frequency tremor causes the image of an object to constantly stimulate cells in the fovea.

Pursuit eye movements

These are conjugate eye movements which smoothly track slowly moving objects in the visual field. They typically require a moving object to elicit them and are not usually under voluntary control. Their purpose, partly, is to stabilise moving objects on the retina thereby enabling us to perceive the object in detail.

Examples: When we watch a rugby football match and follow the ball as it is passed from player to player then we are making pursuit eye movements following the ball. When driving we can use pursuit movements (and other types of eye movements) to monitor the movement of other vehicles on the road.

Smooth eye movements

These are similar to pursuit movements but can be made in the absence of a moving stimulus.

Compensatory eye movements

These are smooth compensatory movements which are related to pursuit movements. They act to compensate for movement of the head or body so as partially to stabilise an object on the retina.

Example: Consider a rugby player is running and at the same time is visually following the flight of a ball, so that he can catch it. He will therefore be making eye movements which compensate both for his body and his head movements as he runs. In driving we make compensatory movements to allow for our head movements which we constantly make.

Vergence eye movements

These are movements where both eyes move in opposite horizontal directions to permit the acquisition of a near or far object. With an object coming towards us then our two eyes move together slightly to maintain binocular vision of it, as the object recedes away from

us then the two eyes diverge again.

Example: When a rugby player is trying to catch a ball coming towards him then he will be tracking the ball visually using a vergence eye movement. In driving we regularly monitor different vehicles around us and use vergence movements to help us do this as some vehicles move away and others approach us.

Nystagmus eye movements

This is a regular form of eye movement, comprising two alternating components – a slow and fast phase. The best example is in a train where looking out of the window you look at a tree and follow it as it moves past (slow phase) then make a rapid movement back (fast phase) and fixate on the next object which again moves past you.

There are several different types of nystagmus.

- *Optokinetic* - This is produced by moving repetitive patterns in the visual field.
- *Vestibular* - This is caused by stimulating the semicircular canals as the head is rotated. A good example is when on a spinning fairground ride where you regularly fixate on an object as it passes (slow phase) and then rapidly make a movement back to fixate on another object. This action is repeated.
- *Voluntary* - This is a pendular movement exhibited by some people where both phases of the nystagmus have a similar velocity and so it is unlike optokinetic or vestibular nystagmus.
- *Latent* - A rare clinical condition where no nystagmus is present but when one eye is covered up then nystagmus occurs.