LETTER TO THE EDITORS

THE FUNCTION OF SMALL SACCADIES

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The eye-movements of fixation may be divided into saccadic and smooth movements.

(i) Saccadic movements which displace the visual axis through distances having median values of 3 to 6 in about 25 ms: maximum speeds of 200/sec are involved. 

(ii) Drift movements, during the intersaccadic intervals, with a duration of about 7.5 and a speed of about 4/sec. 

(iii) Tremor movements: these are irregular movements of excursions less than 1 and speeds ranging up to more than 10/sec.

The magnitudes quoted are from Ditchburn and Foley-Fisher (1967).

Several experiments have been found that some subjects can reduce the frequency of saccades by voluntary control (Barlow, 1952; Clowes, 1961, 1962; Fiori-enti and Escové, 1966; Steinman, Comitz, Timberlake, and Herman, 1967). The median saccadic interval is about 0.8 sec. Steinman et al. find that many subjects can suppress saccades at least for times of trials (Steinman et al., 1971). Klecker, Wyman, Skavenison and Steinman, 1972; Kowler and Steinman, 1977; Steinman and Kowler, 1979) 

Steinman et al. have also shown that subjects who suppress saccades can maintain fixation and can carry out certain visual tasks with good performance. Steinman and Kowler (1979) extend earlier results of Kowler and Steinman (1977) which show that saccades do not improve accuracy of counting elements of repetitive patterns and conclude by saying that "human beings have the skill to make high velocity eye-movements remains a mystery". This letter is intended to elucidate the mystery. 

In normal vision, large saccades of several degrees are used to move the eyes rapidly towards a new target, e.g. when an animal hears a small sound which may indicate the presence of prey or of a predator. Rapid eye-movements have considerable survival value in this situation and it is easy to understand why human beings have not acquired the skill to make them. The main question is why small saccades should occur during fixation. 

Numerous experiments show that the function of the eye-movement control system, during fixation, is to keep the visual axis within a certain small-target area. Very precise fixation would produce the loss of vision which occurs when the retina is stimulated. The drift and tremor movements are mainly determined by the amount of the visual stimulus, in such a way that, from time to time, it strays outside the target area. This stimulates a saccade which usually returns the visual axis to the target area, though not precisely to the centre of this area (Ditchburn and Ginsborg, 1953; Nachmias, 1959; 1961; Beyer, 1967). For some subjects drift movements are almost entirely random but for others more drifts are more corrective than would be expected if they were random as a whole. It appears that some subjects learn to control the drifts well enough to keep the visual axis within the target area for 10/sec or more. The stimulus for saccades is absent and "suppression" of saccades then follows. 

It has been shown (Ditchburn and Drysdale, 1963) that, when a subject views a target with sharp boundaries between areas of different luminance, the drift movements, by themselves, are capable of maintaining fairly good vision. However, Clowes (1962) recorded eye-movements of subjects who fixated a boundary between areas of different hues (e.g. green and blue) with a fairly small luminance difference. He found that, when they suppressed saccades, colour-fusion occurred i.e. the two areas appeared to be of the same hue. When the subjects were instructed to move the eyes so as to prevent colour-fusion, numerous saccades occurred. Clowes (1961) also found that when subjects were allowed and encouraged to move their eyes freely, luminance contrast discrimination was considerably better than it was when they fixated as accurately as possible. Recently, Ditchburn and Foley-Fisher (to be published) have found that when saccades and tremor have been removed by stabilization, imposed movements of the same speed as the natural drifts do not maintain perception of hue. 

Normal eye-movements produce signals which vary with time in receptors near boundaries in the retinal image. The primary visual signal is probably proportional to dL/dt where r is the retinal illumination though higher derivatives of L with respect to t may be involved. A certain minimum signal is needed for threshold vision. dL/dt is proportional to w where r is the component of velocity of the image perpendicular to the boundary and x is the steepness of slope of L at the boundary i.e. the value of dL/dx (where x is a...
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REFERENCES