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LETTER TO THE EDITORS

VISUAL SUPPRESSION DURING SMOOTH FOLLOWING AND SACCADIC EYE MOVEMENTS¹

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OCULOMOTOR activities appear to be controlled by two distinct neural systems: one which regulates saccadic or version movements, and another which controls smooth following movements. The evidence for this derives from (1) the kinds of stimuli eliciting the two types of movements (WESTHEIMER, 1954; RASHBASS, 1961), (2) the nature of the eye's response during the movements (STARK *et al.*, 1962; ROBINSON, 1964, 1965), (3) the contribution of the two types of movements to spatial localization (FESTINGER and CANON, 1965), and (4) the differential effects of central nervous system disease on eye movements (STARR, 1967). We wished to define whether the distinction between the two oculomotor control systems also applied to the phenomenon of visual suppression that accompanies voluntary eye movements (VOLKMAN, 1962; LATOUR, 1962; ZUBER and STARK, 1966). While this phenomenon has been well studied in relationship to saccades, there has been no assessment of vision on oculomotor tasks requiring both types of eye movements. The experiments to be presented in this report measured vision during the tracking of a horizontally moving object and indicate that visual suppression is associated specifically with saccades and not with smooth following movements.

The subjects were four young ladies (ages 16-20) with normal vision and eye movements. Their tasks were (1) to track a slowly moving visual target and (2) to press a button whenever a test flash of light appeared. The subject was seated in a darkened room 150 cm from a screen (50 cm in width), upon which the visual target was projected. The target was a circle of light (approximately 1 cm in dia.) projected from a mirror galvanometer, which moved so as to swing the light sinusoidally across the screen at a frequency of 1, 2, 3, or 4 times/sec. The test flash was generated by a Grass photo-stimulator, and illuminated the screen diffusely. Prior to any tracking, the flash intensity was adjusted for each subject by means of an iris diaphragm to be just visible (correct detection on at least 9 of 10 trials). The subject was then instructed to keep her eyes directed toward the visual target and to press a button, held in the palm, whenever the diffuse test flash appeared. Twenty-five light flashes were presented during a tracking run with intervals ranging from 3-10 sec. The subjects tracked the target at least two times on each of the four tracking frequencies and received a total of at least 200 test flashes. The electro-oculogram, the position of the target light, the time of the test flash, and the subject's response were recorded on magnetic tape and then written out on an ink chart recorder with a time resolution of 1 sec/120 mm of paper. The records were analyzed to determine whether the subject had responded to each test flash and whether

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a saccade had interrupted the smooth pursuit movements within $\frac{1}{2}$ sec, before or after each flash. By this means, the relation between test flash detection and type of eye movements was established.

The results showed that detection of the light flash was affected differently by the two types of eye movements. If the light flash occurred during smooth pursuit, the probability of detection was greater than 85 per cent, approximating detection in the absence of eye movements. Conversely, if the light flash occurred near a saccade, the probability of detecting the light flash was greatly reduced. The results from the four subjects are plotted in Fig. 1 and show detection as a function of the interval between

FIG. 1. To show light flash detection as a function of the onset of saccadic eye movements. The data from four subjects are graphed, and each point represents detection on trials occurring in the interval between that point and the immediately preceding point closer to the light flash.

the test flash and the beginning of a saccadic eye movement. The temporal characteristics of visual suppression followed a time course similar to that described by others (LATOUR, 1962; ZUBER and STARK, 1966). Detection was minimal when the saccade was initiated just prior or just after the light flash, whereas detection was at control levels when the saccade occurred more than $\frac{1}{2}$ sec either before or after the light flash.

Thus, in subjects tracking a slowly moving target, the ability to detect a light flash of threshold intensity was impaired during saccades, but not during smooth following movements. The significance of the distinction in vision between saccadic and smooth following eye movements is not immediately obvious. One possibility is that the neural mechanisms generating saccades affect structures that process visual information and thereby influence perception, whereas smooth following movements do not have this effect. The recent finding that there are changes in electrical activity in lateral geniculate body (FELDMAN and COHEN, 1968; KAWAMURA and MARCHIAFAVA, 1968) and visual cortex (MICHAEL and STARK, 1967) during saccadic movements, but not during smooth movements, bears on this point.

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