

## LETTER TO THE EDITORS

### A COMMENT ON THE "GLISSADE"

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WEBER and DAROFF (1972) recently coined the term "glissade" to describe a slow monocular rotation which corrected unequal binocular saccades. For instance, when the (normal human) subject was asked to look  $30^\circ$  to the right, it was sometimes observed that one eye made a saccade of exactly  $30^\circ$ , and held its new position, while the other eye moved only  $28^\circ$  during a synchronous saccade, but continued to drift the remaining  $2^\circ$  (the glissade). The result was that both eyes turned the same amount, but one did so using a saccade alone, while the other used saccade plus glissade. These movements are sketched in Fig. 1 in the row labelled "eye angle". The authors suggested that glissades are corrective movements, and that their control involves pre-nuclear feedback, a process in which the signal to the

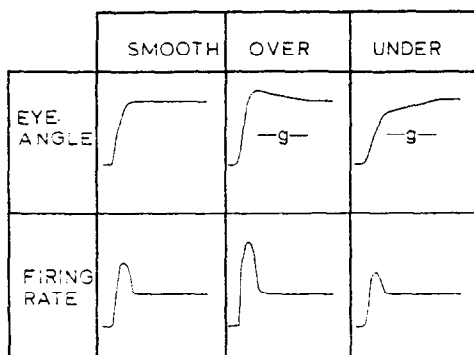


FIG. 1. This illustrates the three kinds of saccades, which smoothly step to the final position, or transiently over- or undershoot it. In the latter two cases, a glissade (g) is used. The lowest row illustrates the hypothetical firing rates underlying the three types. In all cases, the initial and final rates are the same; only the transients differ.

ocular motor nuclei "is monitored at the brain stem level and, if incompatible with the desired output, a corrective movement is generated by the pontine paramedian reticular formation (PPRF). In this instance (i.e. the glissade) where no latency is discernible, the correction is continuous with the saccade. Only an internal monitor could detect asymmetric outflow and rectify the condition 'in flight'" (WEBER and DAROFF, 1972, pp. 472-473).

Such a scheme does account for the data, but there is a simpler explanation available based on electrophysiological analyses of ocular motor nerve signals (FUCHS and LUSCHEI, 1970; ROBINSON, 1970; SCHILLER, 1970). Primate eyes are held in position by opposing muscles; when a shift of gaze is effected, the tone of the agonistic muscle increases, that of the antagonist decreases. This reciprocal change in tone is controlled, of course, by continuous firing of the motor neurons innervating the muscles, but their firing rates do not simply step

up and down; instead, there is a sharp transient associated with the shift in firing rate, as sketched in Fig. 1 in the row labelled "firing rate". The agonistic transient serves mainly to overcome the large viscoelastic load associated with rotating the globe (ROBINSON, 1964). There is a corresponding negative transient observed in the firing rate of the motor neurons to the antagonist. The end result, a smooth monophasic saccade, is dependent on application of two sequentially applied forces; the large initial turning transient which quickly moves the eye to the desired position, and later, the much smaller steady force which holds it there. Obviously, the transient must have magnitude and duration appropriate to the initial and final positions. If it is too large or small, the result will be a saccade which overshoots or undershoots the final position.

I suggest that overshoots and undershoots result from such errors in the transient firing of the motor neurons, and that the glissade, far from being an independently programmed corrective movement, is simply the passive slewing from an unstable position to a new stable position specified by the maintained firing rates of the motor neurons. It would be expected to have a time course similar to that of a vergence movement, for KELLER and ROBINSON (1972) have shown that the latter results from a step change in firing rate, without an initial transient. This expectation is fulfilled, as RASHBASS and WESTHEIMER (1961) reported that vergence velocities are about  $7-10^\circ/\text{sec}/\text{degree}$  of retinal disparity. By analogy, a  $2^\circ$  glissade would be expected to move about  $14-20^\circ/\text{sec}$ . The figure given by Weber and Daroff,  $20^\circ/\text{sec}$ , matches well.

Such a scheme accounts for the glissade quite simply, since it does not require pre-nuclear feedback, but depends only on infrequent errors in the saccadic motor program. Two features are of interest: (1) The simplest way to get the hypothesized error would be if the transient and maintained firing rates were computed separately and the signals specifying these rates converged independently on the ocular motor neurons. Then a mistake could be made in one but not the other. (2) The transients for the two eyes must be computed separately from one another, also, for WEBER and DAROFF (1972) never observed binocular glissades, as would be expected if the saccadic motor programs for both eyes were similarly in error.

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