Summary

We recorded the activity of single neurons in the medial superior temporal (MST) area of the cortex, the dorsolateral pontine nucleus (DLPN), and the ventral paraflocculus (VPFL) of the cerebellum of alert monkeys during ocular following elicited by sudden movements of a large-field pattern. To examine the motor-command generation process for ocular following responses, we quantitatively analyzed the relationship between neuronal firing frequency in each brain region and eye movement or retinal slip by applying linear-regression models for reconstructing the temporal waveform of firing. The coefficients of acceleration, velocity, position, and bias, in addition to the time lag between firing and eye movement/retinal slip were estimated by the least-square error method. As previously reported, the temporal firing patterns of most Purkinje cells (P cells) in the VPFL were satisfactorily reconstructed from eye movement for each stimulus condition (Local Fitting) and for the variety stimulus conditions (Global Fitting) (17 of 20 P cells). By contrast, only 57% (99/175) and 55% (88/160) of the temporal firing patterns taken from 35 MST and 32 DLPN neurons were satisfactorily reconstructed from eye movement for each stimulus condition. Additionally, for the variety stimulus conditions, the firing patterns of two-thirds of the MST and DLPN neurons (25 of 35 for MST, 22 of 32 for DLPN) were only poorly reconstructed from eye movements with a single set of coefficients. These findings indicate that the eye movements during ocular following are not linearly related to neuronal activity in the MST and DLPN, but are linearly related with those in the

VPFL, within the observed stimulus range. However, the temporal firing patterns in the MST and DLPN were satisfactorily reconstructed more often from retinal slips than from eye movement ($P < 0.008$) for the single stimulus condition. For the variety stimulus conditions, the observed temporal firing patterns of the P cells in the VPFL, DLPN, and MST neurons could not be reconstructed from retinal slips of one parameter set. These observations suggest that neurons in the MST and DLPN play a role in detecting the visual motion signal at the preferred direction and speed of each neuron and that the information of temporal firing patterns of these neurons having a variety of temporal and directional characteristics converge on the P cells in the VPFL. Finally, the temporal firing patterns of the P cells appear to represent the motor command utilized by the downstream structures for eliciting ocular following.