

Introduction

Ocular following responses are slow tracking eye movements evoked by sudden drifting movements of a large-field visual stimulus in primates; these responses help to stabilize the eyes on the visual scene. Experiments using monkeys have revealed many features of ocular following (Kawano and Miles 1986; Miles and Kawano 1986; Miles et al. 1986), among the most interesting of which is an observed latency of as short as 50 ms. Considering the delays introduced in the retina and ocular motor plant, the intervening neural elements must be limited in number, suggesting that this system may be amenable to characterization at all stages, from sensory input to motor output. Evidence from single-unit recordings and focal chemical lesions have suggested that early ocular following responses are mediated by a pathway that includes the medial superior temporal (MST) area of the cortex, the dorsolateral pontine nucleus (DLPN), and the ventral paraflocculus (VPFL) of the cerebellum (Kawano et al. 1992, 1994; Shidara et al. 1991, 1993). By means of a linear time-series regression analysis, (Shidara et al. 1993) showed that the simple spike activity of the Purkinje cells (P cells) in the VPFL during ocular following can be reconstructed by an inverse-dynamics representation which uses the acceleration, velocity, and position of eye movement. This successful reconstruction suggested that the firing frequency of the P cells represents the motor command utilized by the downstream structures for eliciting ocular following. It then remained

to be determined whether the cerebellum is the site for transforming the visual inputs into the motor command. If this motor command is already represented in the inputs to the P cells, then the firing patterns of the neurons providing the inputs could also be reconstructed by an inverse-dynamics representation of the eye movements.

To elucidate the source of visual inputs to the P cells in the VPFL during ocular following, we previously reported that neurons in the MST and DLPN respond to movements of a large-field visual stimulus that elicit ocular following (Kawano et al. 1992, 1994). Our data suggested that these neurons play a role in eliciting ocular following. To examine the dynamic characteristics of these neural activities, we attempted to reconstruct the temporal firing patterns of the MST and DLPN neurons with the same second-order linear-regression model (inverse-dynamics representation) using the acceleration, velocity, and position of the eye movements. We also analyzed the relationship between the information associated with retinal slip and the activity of neurons in the MST, DLPN, and VPFL, which represent different stages of processing, from sensory input to motor output.

Based on our results, we provided a hypothesis of spatio-temporal sensory-to-motor transformation processing in ocular following. Preliminary results from these analyses have been presented elsewhere (Takemura et al. 1996).