Frontal eye field input neurons have higher spontaneous firing rates and narrower action potentials than output neurons

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The frontal eye field (FEF) is reciprocally connected with the superior colliculus (SC), and we previously identified two critical types of FEF neurons in this circuit. In response to a brief pulse of current in the SC, FEF input neurons are orthodromically activated while FEF output neurons are antidromically activated. The route of orthodromic activation of FEF input neurons, however, is controversial. We have presented many lines of evidence indicating that the input neurons are driven through an SC-thalamus-FEF pathway, but an alternative explanation is that they are activated via collaterals of corticotectal neurons (discussed in Sommer & Wurtz 1998, 2004). Here we test our hypothesis in a new way. The hypothesis implies that FEF input neurons primarily reside in thalamic-recipient layer IV, which contains a large proportion of interneurons. One feature of interneurons is that they exhibit higher spontaneous firing rates and narrower action potentials than pyramidal neurons (e.g. Constantinidis and Goldman-Rakic 2002; Rao et al. 1999; Simons 1978; Swadlow 1995). FEF output neurons, in contrast, are entirely pyramidal and reside in layer V (Fries 1984). Our hypothesis would be supported if FEF input neurons, which may consist largely of interneurons, exhibit higher spontaneous firing rates and narrower action potentials than FEF output neurons, which are homogeneously pyramidal. We studied 27 FEF input neurons and 67 FEF output neurons from four monkeys. To test the hypothesis, we 1) measured each neuron's spontaneous firing rate and action potential width and 2) categorized each FEF input neuron as a putative inhibitory interneuron or a putative pyramidal neuron by plotting spontaneous firing rate vs. action potential width. We found, first, on average, FEF input neurons did have higher average spontaneous firing rate and narrower action potential widths. Second, we found that about a half of the FEF input neurons reliably fell outside of a calibration cluster of pyramidal neurons in the plot. In conclusion, many FEF input neurons have higher spontaneous firing rates and narrower action potentials than FEF output neurons. These findings suggest that FEF input neurons may consist largely of interneurons, supporting our hypothesis that FEF input neurons reside in layer IV and are driven via thalamic input.