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Abstract: Following a recent study [1], we asked whether an analysis of spike waveforms could reveal distinct neural populations with different functional properties in the middle temporal area (MT) of the macaque.

To identify distinctive waveform features, we used an unsupervised clustering algorithm based on a sorting and classification technique that combines the wavelet transform with superparamagnetic clustering [2]. We applied the waveform analysis to neuronal responses recorded extracellularly from area MT of five awake rhesus monkeys that fixated a central fixation point while a whole-field dot pattern moved on a circular motion trajectory in the frontoparallel plane. Over time this stimulus maps out all directions of translational motion and provides a quantitative measure of direction preference, and the sharpness of direction tuning [3].

We defined spike waveform duration as the time in microseconds between trough and peak, and found a clear bimodal distribution of this waveform duration among the MT neurons. This allowed us to identify a narrow- and a broad-spiking subpopulation of neurons on the basis of the two modes of this distribution. Once these subpopulations had been identified we investigated their spiking statistics to corroborate their identification with morphologically distinct neuron classes. The inter-spike interval (ISI) statistics of the narrow-spiking population resembled those of a Poisson process, whereas the ISI statistics of the broad-spiking population showed clear burstiness. Moreover, the peak firing rate in the narrow-spiking subpopulation was significantly higher than that in the broad-spiking population. These characteristics suggest that the subpopulations indeed correspond to interneurons (narrow-spiking) and pyramidal cells (broad-spiking).

Next, we investigated the functional properties of these populations and found clear differences in the direction tuning properties. First, direction-tuning was significantly sharper in the narrow-spiking population than in the broad-spiking population. Second, while the broad-spiking population had a uniform distribution of preferred directions, the narrow-spiking population had a clear preference for cardinal directions of motion.

We conclude, first, that MT neurons can be classified based on their spike-waveform and this classification likely corresponds to anatomically distinct classes of neurons. Second, the putative interneurons in MT are more sharply tuned for direction and the cardinal bias of direction preference reported previously [4] is a property that is unique to these interneurons. These distinct functional properties shed new light on motion processing in MT and need to be integrated into biologically plausible models of motion analysis.

References

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