Spatiotemporal integration properties in MT neurons affect motion discrimination

Perception requires integrating noisy dynamic visual information across the visual field to identify stimuli and guide conscious decisions. While the temporal integration process has been studied extensively in experiments with highly controlled visual stimuli and reverse-correlation techniques, the nonlinear mechanisms underlying spatial integration are often neglected. Here, we show that the spatial structure of the stimulus modulates neural responses in visual cortex and impacts perceptual choices. In particular, we find that monkeys integrate spatial evidence sublinearly in a motion discrimination task due to (i) surround suppression effects causing an attenuation of the responses to motion in the center of the stimulus, and (ii) weaker impact of motion further away from the fovea. To test whether these effects originate in the Middle Temporal area (MT), we estimate and validate the spatiotemporal direction sensitivity kernels of MT neurons using nonlinear regression models. Compared to a similar temporal integration model, the model's predictive accuracy in held-out trials was significantly enhanced by including nonuniform spatial weighting profiles. We identified heterogeneous direction preference in the receptive fields of MT units. Moreover, our results show that the impact of motion on MT spiking decreases consistently with distance to the fovea. Our findings can be synthesized in a two-stage model of perceptual decision making in which spatial context effects modulate spatial stimulus integration in neurons of visual cortex, and a decision area supports temporal integration to give rise to perception. Taken together, our work challenges the assumption that spatially distributed stimuli are integrated uniformly and calls for a new class of decision making models that take into account spatial processing.