The Origin of Adaptive Temporal Integration in Visual Cortex
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Characterizing visual neurons in terms of spatio-temporal receptive fields (RFs) involves determining their profiles of spatial and temporal integration. In many V1 cells, however, these profiles are not fixed, but vary substantially with changes in the visual stimulus used to map the RF. For example, the temporal integration window for complex direction selective (CDS) cells in macaque V1 varies systematically with temporal frequency (TF), spatial frequency (SF), and contrast\textsuperscript{1}. In particular, integration is short-lived for rapidly moving stimuli and prolonged for slower stimuli. Currently, the mechanisms and loci of these apparently useful features of sensory processing remain unknown. If models of visual processing are to accurately predict responses to arbitrary stimuli, non-linearities such as this adaptive temporal integration (ATI) must be accounted for.

To determine where ATI arises, we assessed temporal integration in classes of cells that might lie upstream from V1 CDS cells, including simple DS, simple non-DS, and LGN cells. All data were recorded extracellularly from single units in anesthetized macaque monkeys. We used the same type of randomly moving sinusoidal grating stimulus\textsuperscript{1} that was used previously for CDS cells. We quantified temporal integration for DS simple cells using the width at half-height of the motion-domain spike-triggered average (STA). For non-DS simple cells and LGN cells, the motion-domain STAs were flat. These cells have a clear preference for the spatial phase of a sinusoidal grating; therefore, we transformed the stimulus sequence to a weighted toward-away representation in which each movement was coded as taking the stimulus toward or away from the preferred spatial phase. We computed toward-away STAs and deconvolved them to remove the influence of the stimulus autocorrelation in time.

For V1 simple DS cells, we found that temporal integration changes with the stimulus speed in a manner similar to that observed for CDS cells, spanning a range from about 60-70 ms for slow motion to about 20 ms for fast motion. This demonstrates that ATI is not exclusively a property of complex cells. Also, for the handful of simple non-DS cells that we have tested, we observed little change in temporal integration compared to that for DS cells. Preliminary data from the LGN suggest that some magnocellular cells increase their integration time consistent with ATI seen in the cortex.

It is still too early to make firm conclusions, but the results emerging so far are consistent with the idea that adaptive temporal integration may be a property of the motion pathway, including V1 DS cells (both simple and complex) and magnocellular cells in the LGN.

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References