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Computational mechanisms for the recognition of time sequences of images in the visual cortex

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Abstract: Despite significant scientific progress in understanding how the brain processes complex spatial patterns in still images, relatively little is known about the computational mechanisms underlying the processing of temporal sequences of images. Previous work pointed to a key role for the superior temporal polysensory area (STP) in the representation of time sequences of images (e.g., Oram & Perrett, 1996). While the STP receives convergent inputs from both the ventral and the dorsal streams, how much of the selectivity observed depends on shape vs. motion information remains a matter of debate (Giese & Poggio, 2003; Lange & Lappe, 2006). Here we use computational tools in conjunction with monkey behavioral and electrophysiological data to address this outstanding question and try to characterize the neural circuits involved in the processing of dynamic action stimuli.
Using computer generated biped or hand action sequences, we trained monkeys to recognize multiple actions and recorded from the temporal lobe of the visual cortex (Singer & Sheinberg, SFN 2008). Cells exhibited selectivity for action, character identity, and/or their combination; more than half of all selective cells exhibited selectivity for the action being performed. We use computational models of the ventral (Serre et al, 2005) and dorsal streams (Jhuang et al, 2007) to test the relative contribution of shape vs. motion information in shaping the selectivity of these cells in response to various stimulus presentations. We find that, computationally, motion information as provided by the model of the dorsal stream provides a better cue for the action recognition task. However, while no part of the model in isolation could account for the neural selectivity observed across stimulus presentations, we found that overall the ventral stream may contribute more to the selectivity observed than previously anticipated. Finally, we use the computational models to make a number of testable predictions for further experiments.
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: Normal vision is not static: time is a key dimension of the natural world we see. The eventual understanding of biological vision requires understanding the neural mechanisms used to recognize objects and actions over time. However, despite significant scientific progress in understanding how the brain processes complex spatial patterns in still images, relatively little is known about the computational mechanisms underlying the processing of temporal sequences of images. We present initial attempts to uncover such computational mechanisms.

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