Associative learning in cortical visual area MT of macaque monkeys

A. Schlack, T.D. Albright

When two stimuli are frequently seen together, the sight of one often elicits the thought or image of the other. This associative learning is frequently thought of as a high level process and evidence suggests that it may be mediated by plastic changes in the stimulus selectivities of neurons in the inferior temporal cortex (Miyashita et al., Messinger et al.). We sought to determine whether associative learning-induced neuronal plasticity is limited to this high-level visual processing stage, or whether it is a more general property that is also present at earlier processing stages.
To achieve this goal, we trained monkeys to behaviorally associate naturally effective stimuli for neurons in area MT (i.e. translatory motions) with arbitrary non-effective stimuli (static 2D patterns). For example, we trained animals to associate leftward and rightward moving patches of dots with stationary leftward and rightward pointing arrows. We hypothesized that learning of the behavioral association would be paralleled by the emergence of selective neuronal responses to the static stimuli. We recorded from MT neurons before training began and after training was complete to a criterion of 80% correct performance.
Before training, only 4% of the neurons (i.e. less than chance) showed selective responsiveness to the stationary stimuli. After training this percentage increased to 17%. For 80% of these neurons, selectivity for the stationary stimulus was detectable in the neuronal response 70 ms following stimulus onset. Remarkably, the preferred static stimulus for a given neuron tended to be the one that the monkey had learned to associate with the preferred direction of motion for that neuron. This result was highly significant over the population of neurons recorded ($p<0.001$). Thus the stimulus selectivities of many neurons in area MT, a relatively early visual processing stage, are plastic and selectively modifiable by associative learning. The short latencies of these “trained” responses suggest that they may result from local hebbian plasticity, rather than feedback from higher visual areas.