Computational Neuroscience Seminar

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Modulating gain: cholinergic mechanisms in macaque V1

Cholinergic neuromodulation is a candidate mechanism for arousal and attention in mammals. Acetylcholine (ACh) is released in cortex by volume transmission and so specificity in its effects upon cortical circuits must largely be conferred by selective expression of ACh receptors (AChRs). To dissect the local circuit action of ACh, we use quantitative anatomical methods and in vivo physiology and pharmacology to determine the effects of, and mechanisms behind, the local actions of cholinergic agonists during visual stimulation in the macaque primary visual cortex (V1). We have shown that nicotinic ACh receptors are found presynaptically at thalamocortical synapses arriving at spiny neurons in layer 4c of macaque V1 and that nicotine acts in this layer to enhance the gain of responses to visual stimuli. Similar evidence for nicotinic enhancement of thalamocortical transmission has been found in the primary cortices of other species and across sensory systems (olfaction, somatosensation, audition, and vision). In separate experiments we have shown that, amongst intrinsic V1 neurons, a higher proportion of GABAergic – in particular parvalbumin-immunoreactive - neurons express muscarinic ACh receptors than do excitatory neurons. We have also shown that ACh strongly suppresses visual responses in layers 2, 3, 5, and 6 of macaque V1 and that this suppression can be blocked using a GABAa receptor antagonist. Suppression by ACh has been demonstrated in a number of cortical model systems but is more often found to be mediated by reduced glutamate release rather than enhanced GABA release as is the case in macaque V1. I will discuss recent anatomical data on the expression of m1 ACh receptors in other cortical areas of the macaque, and in V1 of other species. I will discuss the evidence for (and against) the notion of a "canonical cholinergic cortical circuit" that can be applied across neocortical model systems.