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13h30, Room AAC 008

Computational Neuroscience Seminar

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High dimensional brains: the computational advantages of the diversity of neural responses

Single-neuron activity in prefrontal cortex (PFC) is often tuned to mixtures of multiple task-related aspects. Such mixed selectivity is highly heterogeneous, seemingly disordered and difficult to interpret.

Because of its prominence in PFC, it is natural to ask whether such heterogeneity plays a role in subserving the cognitive functions ascribed to this area. We addressed this question by analyzing the neural activity recorded in PFC during an object sequence memory task. We show that the recorded mixed selectivity neurons offer a significant computational advantage over specialized cells in terms of the repertoire of input-output functions that are implementable by readout neurons. The superior performance is due to the fact that the recorded mixed selectivity neurons respond to highly diverse non-linear mixtures of the task-relevant variables. This property of the responses is a signature of the high-dimensionality of the neural representations. We report that the recorded neural representations have actually the maximal dimensionality. Crucially, we also observed that this dimensionality is predictive of animal behavior. Indeed in the error trials the measured dimensionality of the neural representations collapses. Surprisingly, in these trials it was still possible to decode all task-relevant aspects, indicating that the errors are not due to a failure in coding or remembering the sensory stimuli, but instead in the way the information about the stimuli is mixed in the neuronal responses. Our findings suggest that the focus of attention should be moved from neurons that exhibit easily interpretable response tuning to the widely observed, but rarely analyzed, mixed selectivity neurons.

Work done in collaboration with: M. Rigotti, O. Barak, M. Warden, X-J.Wang, N. Daw, E.K. Miller.