A motor readout of visual perception:

Deciphering cuttlefish camouflage at single-chromatophore resolution

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Cuttlefish provide a unique opportunity to study visual perception in an animal whose eyes, brain, and motor control strategy evolved independently of the vertebrate lineage (Kröger et al. 2011). These animals possess the most advanced camouflage in the animal kingdom, displaying their perception of the visual environment as a two dimensional image on their skin. This is accomplished through direct neural control over the expansion and contraction of hundreds of thousands of pigment-filled cells known as chromatophores. How does the cuttlefish perform the mapping from visual scene to camouflage pattern choice? As a first step towards answering this question, we sought to describe cuttlefish camouflage quantitatively. We developed a multi-level video-analysis pipeline to track tens of thousands of chromatophores simultaneously at 60 frames per second. In addition, non-affine image registration using small patches of skin as uniquely identifiable features allowed us to stitch together datasets separated in time by up to weeks. By factorizing the resulting chromatophore area x time matrix, we could infer putative elements of a hierarchical motor control strategy. This starts with motor neurons directly coordinating the activity of small groups of chromatophores and proceeds to larger-scale pattern elements. These measurements were validated and extended by in vitro experiments where motor neuron innervation was assessed physiologically through electrical stimulation. Further, taking advantage of our ability to track single chromatophores over developmental timescales, we detected and studied the continuous integration of large numbers of newly developed chromatophores into the exiting circuit. We are currently investigating how the simple, local developmental rules that seem to govern this system are consistent with the large numbers of camouflage patterns cuttlefish are able to adopt. Our approach provides the first view of cephalopod skin patterning at the spatiotemporal scale of the nervous system. More generally, it uses the unique features of an atypical model to provide a nearly complete readout of visual perceptual behavior at single-cell resolution in a freely moving animal.

コウイカが擬態に用いる体色変化に関する研究成果を講演してもらいます。学部生も聴講自由です。

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