Neural Structure for Integrating Visual Signals with Those of Other Modalities

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Extensive studies suggest that the brain integrates visual signals with those of other modalities in a Bayesian optimal way. Hence it is natural that the so-called "congruent" cells play an important role in signal integration, since they respond similarly to visual cues and those of other modalities. However, experiments revealed that where visual and vestibular cues are integrated to infer heading direction in the brain, "opposite" cells exist with roughly the same number. Their computational role remains largely unknown. We propose that opposite neurons may serve to encode the disparity information between cues necessary for multisensory segregation, and build a computational model composed of two reciprocally coupled modules, each consisting of groups of congruent and opposite neurons. Our model reproduces the characteristics of congruent and opposite neurons, and demonstrates that in each module, congruent and opposite neurons can jointly achieve optimal multisensory information integration and segregation.

In the second part of this presentation, we will consider how Bayes-optimal neural structures are shaped by the correlation between the visual signals and those of other modalities in the prior information. We found that both the reciprocal couplings between multisensory areas and the feedforward crosslinks are crucial to optimal multisensory integration. On the other hand, the same-side feedforward and recurrent connections will adapt to changes in the sensory reliabilities rather than to changes in the correlation between stimuli. This study sheds light on how the brain implements optimal multisensory integration and segregation concurrently in a distributed manner.