Concurrent Multisensory Integration and Segregation with Complementary Congruent and Opposite Neurons

Wen-Hao Zhang

Department of Mathematics, University of Pittsburgh, US

Email: wenhao.zhang@pitt.edu

Abstract:

Our brain perceives the world by exploiting multiple sensory modalities to extract information about various aspects of external stimuli. If these sensory cues are from the same stimulus of interest, they should be integrated to improve perception; otherwise, they should be segregated to distinguish different stimuli. In reality, however, the brain faces the challenge of recognizing stimuli without knowing in advance whether sensory cues come from the same or different stimuli. To address this challenge and to recognize stimuli rapidly, we argue that the brain should carry out multisensory integration and segregation concurrently with complementary neuron groups. Studying an example of inferring heading-direction via visual and vestibular cues, we develop a decentralized network model which consists of two reciprocally connected modules, the dorsal medial superior temporal area (MSTd) and the ventral intraparietal area (VIP), and that at each module, there exists two distinguishing groups of neurons, congruent and opposite neurons. Specifically, congruent neurons implement cue integration, while opposite neurons compute the cue disparity, both optimally as described by Bayesian inference. The two groups of neurons provide complementary information which enables the neural system to assess the validity of cue integration and, if necessary, to recover the lost information associated with individual cues without re-gathering new inputs. Through this process, the brain achieves rapid stimulus perception if the cues come from the same stimulus of interest, and differentiates and recognizes stimuli based on individual cues with little time delay if the cues come from different stimuli of interest. Our study unveils the indispensable role of opposite neurons in multisensory processing and sheds light on our understanding of how the brain achieves multisensory processing efficiently and rapidly.