BMC Neuroscience

Oral presentation

Stimulus encoding and correlates with behavior in area MT of visual cortex is dependent on spike phase

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from Sixteenth Annual Computational Neuroscience Meeting: CNS*2007
Toronto, Canada. 7–12 July 2007

Published: 6 July 2007

BMC Neuroscience 2007, **8**(Suppl 2):S26 doi:10.1186/1471-2202-8-S2-S26

How is the activity of neurons in the sensory areas of cortex related to our perceptual abilities? Past studies have suggested that sensory neurons that best encode a visual stimulus are also more influential in forming the perception of the stimulus. We wanted to know if this relationship also extended to individual action potentials. If some spikes encode the stimulus better than others, then would these same spikes have more weight in supporting the perceptual behavior?

To address this question, data from a past motion detection experiment was analyzed [1]. In this study, two monkeys were trained to detect the onset of coherent motion in a random dot patch that initially contained 0% coherent motion. The coherent motion signal occurred at a random time and the animals were rewarded for responding within a 750 ms window. Extracellular recordings were made from single neurons in the Middle Temporal (MT) area. The random dot patch overlapped the receptive field of the neuron and the coherent motion was matched to the neuron's preferred direction and speed. Importantly, the position of the random dots was only updated once every 27 ms. Because of the slow motion update rate, the neural activity of many of the MT neurons oscillated at the same frequency as the motion updates. It was these oscillations that allowed us to ask if some spikes were more influential than others by measuring how sensory and choice related information varied as a function of the phase of the oscillation.

To determine whether some spikes encoded the stimulus better than others, we examined the difference between spikes on the rising phase of the oscillation (from the trough to the peak) compared to spikes on the falling phase (peak to trough). Using the spike-triggered average of the motion stimulus, we found that spikes did not equally represent sensory information. Spikes occurring during the rising phase of the stimulus-induced oscillation encoded stronger motion than spikes occurring during the falling phase. Importantly, the same spikes that encoded stronger motion were also more correlated with the animal's behavioral performance and reaction time. This suggests that the spikes carrying the most reliable task related information are more strongly linked to the behavioral decision. In addition, these results support the hypothesis that phase could be used as a possible encoding scheme during neuronal oscillations.

Acknowledgements

Supported by CIHR and NSERC.

References

1. Cook EP, Maunsell JHR: **Dynamics of neuronal responses in macaque MT and VIP during motion detection.** *Nature Neuroscience* 2002, **5:**985-994.