BMC Neuroscience

Poster presentation

Neuronal firing patterns and cerebral cortical functions

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from Eighteenth Annual Computational Neuroscience Meeting: CNS*2009
Berlin, Germany. 18–23 July 2009

Published: 13 July 2009

BMC Neuroscience 2009, **10**(Suppl 1):P106 doi:10.1186/1471-2202-10-S1-P106

This abstract is available from: http://www.biomedcentral.com/1471-2202/10/S1/P106

Introduction

Brodmann's map constructed on the basis of cellular organization has been useful as a functional map of the cortical areas, such as the sensation, association, and motion. Since cytoarchitectually distinct cortical areas have different arrangements, density, and types of neurons, it is reasonable to expect that neuronal signaling patterns may reflect the structures, and effectively operate for their specific computations. In order to examine the intrinsic relationship between neuronal firing signals and cortical functions as well as cellular structures, we develop a metric that may extract intrinsic non-Poisson irregular firing characteristics from a spike train in isolation from the firing rate fluctuation of extrinsic origin. Using a metric of local variation *Lv* that measures the cross-correlation of consecutive ISIs rescaled with instantaneous rate [1,2], we revealed that the firing regularity remains fairly invariant with time and rate fluctuation for individual neurons. However, it was reported that another metric measuring the instantaneous irregularity similar to *Lv* varied in time and with behavioral contexts in another experiment [3]. This fact indicates that the local firing metrics suggested so far are still inadequate for extracting the intrinsic firing characteristics in isolation of the extrinsic perturbation. Here we revise *Lv* into a new metric by enhancing the firing rate invariance, which allows the signaling patterns specific to individual neurons to be detected more sensitively, and conduct an analysis to reveal the difference of intrinsic firing dynamics among the cortical areas.

Using the revised metric, we analyze spike trains from a large number of neurons recorded in eight laboratories from fifteen cerebral cortical areas. The two-dimensional map contracted by multidimensional scaling from the firing-pattern dissimilarities across the cortical areas reveals a gradient of the firing regularity in close correspondence to the functional categories of the cortical areas. Neuronal firing patterns are regular in the primary and higher-order motor areas, random in the visual areas, and bursty in the prefrontal area. These results indicate that the neuronal signaling patterns not only reflect the cortical structures, but also play a crucial role in the cerebral cortical computation specific to their functional categories.

Acknowledgements

We thank Nanae Matsuno, Shintaro Funahashi, Keisetsu Shima, Ichiro Fujita, Hiroshi Tamura, Taijiro Doi, Kenji Kawano, Naoko Inaba, Kikuro Fukushima, Sergei Kurkin, Kiyoshi Kurata, Masato Taira, Ken-Ichiro Tsutsui, Hidehiko Komatsu, Tadashi Ogawa, Kowa Koida, Jun Tanji, and Keisuke Toyama for their helpful discussion. This study was supported by Grants-in-Aid for Scientific Research on Priority Areas, System study on higher-order brain functions, from MEXT, Japan.

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