Rate Latency Patterns Across Neuronal Populations Specific to Behavior

Emanuele Lucrezia[1], Pietro Quaglio[1], Alexa Riehle[2], Junji Ito[1], Sonja Gruen[1,3]

[1] **Institute of Neuroscience and Medicine (INM-6), Institute for Advanced Simulation (IAS-6), JARA Brain Institute I (INM-10)**

[2] **INT, CNRS-AMU, Marseille, France**

[3] **Theoretical Systems Neurobiology, RWTH Aachen University, Aachen, Germany**

Contact: `e.lucrezia@fz-juelich.de`

Keywords: *clusters/brain regions; physiology; computational biology; brain network; neural activity dynamics; electrophysiology; Rate Latency; Rank Order Coding.*

Motor cortices neurons change their firing rates in relation to movement of body parts. The timings of the peak firing rates differ across simultaneously observed neurons. Several studies related to other cortical areas (e.g. [1]) have shown that the order of the peak latencies encode information processed in the local network. Here we perform latency ordering analysis of neuronal recordings from macaque motor cortex during a reach-to-grasp task [2]. Specifically we aim to characterize if neurons exhibit the same rate latency order across trials, and if this order is specific to the behavioral context. Two macaque monkeys were trained to perform a reach-to-grasp task [2], where the monkeys were required to reach to an object, hold it with a specific grip type (side grip (SG) or precision grip (PG)), and pull it at a specific force level (high or low). Two cues for the grip type and the force level were provided intervened by a 1 sec delay: the first cue presents the grip type and the second the force level. The second cue was also the go signal for the monkey to initiate the reaching to the object. Trials with different combinations of grip type and force level were performed in a pseudo-random order. During the task performance, spiking activities of single neurons were recorded from the motor cortex (M1/PMD) using a 10x10 Utah electrode array, which enabled to record spike trains of more than 100 single neurons simultaneously. In order to obtain the timing of the movement related spiking activity of single neurons, we estimated the instantaneous firing rate in each individual trial using a kernel convolution method [3] and performed a statistical test [4] to detect significant changes in the firing rate. We register the time latency from the onset of the arm movement to the time of the peak of the firing during a significant rate change. Thus, for each trial we obtain a set of peak latencies for the simultaneously recorded single neurons. We first confirm if neurons exhibit the same latency order across the trials of the identical task condition. We quantify the similarity between the latency order of each pair of trials by the Spearman's rank correlation, and test whether the distribution of the correlation coefficients among the trial pairs are significantly different from the distribution obtained from randomly shuffled latency combinations. For both monkeys we analyzed and for both behavioral trial types (SG and PG) the empirical data exhibit significantly stronger correlations than the surrogates, indicating that the latency order is more consistent across trials (of an identical condition) than expected from the random latency combination. Further we examined if the latency order is specific to the behavioral context. We test whether or not the empirical distributions of the correlation coefficients within trials of identical conditions significantly differ from the distribution obtained from pairs of trials randomly selected from different conditions. For one monkey we find that the latency order correlation is significantly stronger within identical conditions than between different conditions, while for the other monkey there is no significant difference.

A possible reason for this difference may rest on the fact that the task performance, in terms the movement reaction time and success rate, of the latter monkey was much faster and better than the former, which may imply that the movement was already well prepared during the delay period. We are currently examining how the inter-trial variability of the reaction time is reflected in the neuronal activity on a single trial basis, which would shed light on the neuronal mechanism determining the task performance and its inter-subject differences

Acknowledgements. *Supported by EU Grant 785907(HBP) and EU Grant 720270(HBP)*

References

[1] Riehle, A., Wirtssohn, S., Grün, S., and Brochier, T. (2013). Frontiers in Neural Circuits , 7:48.

[2] Luczak, A., McNaughton, B. L., and Harris, K. D. (2015). Nature Reviews Neuroscience, 16(12):745.

[3] Nawrot, M. P., Aertsen, A., and Rotter, S. (1999). Journal of Neuroscience Methods , 94(1):8192.

[4] Baker, S. N. and Gerstein, G. L. (2001). Neural Computation, 13(6):1351137