ANALYSIS OF SPIKE SYNCHRONIZATION IN MASSIVELY PARALLEL SPIKE TRAINS. II: RESULTS FROM MACAQUE MOTOR CORTEX DURING AN INSTRUCTED-DELAY REACH-TO-GRASP TASK

PIETRO QUAGLIO

ABSTRACT. Cell assemblies (Hebb, 1949) exhibiting neuronal interactions at the millisecond scale were suggested as building blocks of information processing in the brain. Thus, significant patterns of synchronous spikes in electrophysiological recordings are considered as a signature of an active assembly. The Unitary Event analysis (Grün et al, 2002a; Grün et al, 2002b) demonstrated the presence of synchronous spike patterns in relation to motor planning and execution in simultaneous recordings of a few neurons (e.g. Riehle et al, 1997; Kilavik et al, 2009). We recently developed a novel statistical method - called Spike Pattern Detection and Evaluation (SPADE) analysis (Torre et al, 2013) - to detect higher-order spike patterns in massively parallel recordings on the order of 100 or more neurons. We apply the SPADE analysis in its time continuous version to electrophysiological data recorded from the motor cortex of two monkeys (macaca mulatta), while they repeatedly executed a delayed reach-to- grasp motor task. Monkeys were trained to grasp, pull and hold an object in a narrow window position to get a food reward. The object was either heavy or light to pull, and could be grasped by using either a full-hand side grip or a two-fingers precision grip. To allow the monkey to prepare the upcoming movement, the animal was instructed on which grip modality and force level to use by two successive visual cues presented before movement onset. Massively parallel spiking activity was recorded by using a 96 electrode Utah array, chronically implanted at the MI/PMd border (Riehle et al, 2013).

We work under the assumption that a specific behavior or stimulation may require the activation of specific cell assemblies. Therefore, we hypothesize that different classes of spike patterns occur in different behavioral conditions and at different times in the trial. Thus, recordings of the same neurons are analyzed and compared across the 4 different behavioral conditions (combination of object load and grip type), and across 6 time epochs within each trial which we defined based on different stages of the task protocol. We find for both monkeys a multitude of patterns with a preferential alignment along the medio-lateral orientation. The patterns are specific the time epochs and the grip modality, but not to the force level. The patterns often overlap in terms of composing neurons. We identify classes of similar patterns using a clustering approach based on the overlap of neuron identities. The resulting classes of similar patterns are not specific to the behavioral conditions and epochs. This suggests that the same neuron may belong to different cell assemblies that become active in different behavioral conditions.

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PHD STUDENT, NSTITUTE OF NEUROSCIENCE AND MEDICINE (INM-6) AND INSTITUTE FOR ADVANCED SIMULATION (IAS-6) AND JARA BRAIN INSTITUTE I, JÜLICH RESEARCH CENTRE, JÜLICH, GERMANY

E-mail address: p.quaglio@fz-juelich.de