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Poster presentation

Modifications in motor cortical spiking dynamics induced by practice

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The planning of goal-directed movements requires sensory, temporal and contextual information to be combined. Cortical neurons selectively modulate their activity in relation to information about spatial and temporal movement parameters [1]. It is commonly accepted that perceptually and behaviorally relevant events are reflected in changes in firing rate in widely distributed populations of neurons. The temporal coding hypothesis suggests that not only changes in firing rate, but also precise spike timing constitute an important part of the representational substrate for perception and action. Precise spike timing here refers to spike synchronization or other precise spatio-temporal patterns of spike occurrences among neurons organized in functional groups, commonly called cell assemblies. We have shown that the strength of precise spike synchrony among pairs of motor cortical neurons modulates in time, independent of the firing rate modulation of the neurons [2]. Furthermore, the timing of the modulation of both synchrony and firing rate at the level of neuronal populations suggests that synchronous neuronal activity may be preferentially involved in early preparatory and cognitive processes, including signal expectancy [2], whereas the modulation in firing rate may rather control movement initiation and execution [3].

Here we asked whether daily practice in a motor task induces long-term modifications in the temporal structure of both synchrony and firing rate at the population level in motor cortex. Three monkeys were trained in a delayed choice-reaction time task in which the selection of movement direction depends on correct time estimation [1]. The activity of simultaneously recorded single neurons was analyzed with the Unitary Event technique [4,5]. Our data show that the timing inherent to the motor task is represented in the temporal dynamics of significant spike synchronization at the population level. In addition, the temporal dynamics of synchrony becomes more structured with practice. In particular, significant synchrony becomes more localized in time during late experimental sessions compared to early ones, with a strong increase in synchrony when, as a function of GO signal expectancy, directional movement preparation has to be updated. In parallel, the behavioral performance improves with practice and the average population firing rate mainly decreases. The firing rates of the neurons are also modulated in time, albeit with a different time course than spike synchrony. In addition, whereas the time course of synchrony modulation is similar in all three monkeys, the time course of firing rate modulation is different.

We conclude that the dynamics of precise spike synchrony at the population level not only modulates in relation to the behavioral task, but is also shaped by practice. This suggests that precise spike synchrony represents an additional and independent coding dimension to firing rate modulations, possibly allowing improved behavioral performance with practice. Performance optimization might therefore be achieved by boosting the computational contribution of spike synchrony, allowing an overall reduction in population activity.

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