DECODING COVERT ATTENTION FROM SIMULTANEOUS RECORDINGS IN PREFRONTAL AND VISUAL CORTEX

Panagiotis Sapountzis[1,†,], Stelios Anastasakis[2,†], Robert Desimone[3], Georgia G. Gregoriou[1,2]*

[1] Foundation for Research and Technology-Hellas (FORTH), Heraklion, Greece
[2] Graduate Program in the Brain and Mind Sciences, University of Crete, Heraklion, Greece
[3] McGovern Institute for Brain Research, MIT, Cambridge, Massachusetts, USA
† equal contribution
[*] pasapoyn@iacm.forth.gr

The use of machine learning algorithms for the decoding of neuronal signals has been rapidly increasing in neuroscience literature. Such techniques are primarily employed for the control of brain-machine interfaces (BMIs) that allow patients with mobility impairments to operate assistive equipment. Although research has mainly focused on the decoding of sensory and motor signals, the application of neuronal decoding to study cognitive, endogenous, processes could facilitate the development of more efficient BMIs and also improve our understanding of how these processes are represented in the brain. The ultimate goal of real-time decoding of cognitive states can only be achieved through simultaneous recordings of neuronal signals from multiple sites either within a single brain area or across different areas. However, it remains an open question whether recordings from different areas can improve decoding performance.

It is known that activities in the Frontal Eye Field (FEF) and area V4 are modulated by and synchronized during covert attention, with the FEF providing top-down feedback to V4. In this study, we used simultaneous recordings to examine whether signals from the two areas can be used to decode the locus of spatial attention. Recordings were carried out in two rhesus monkeys engaged in a covert attention task (Gregoriou et al., 2009). In each recording session up to four microelectrodes were lowered in each area to record spikes and Local Field Potentials (LFPs). A Support Vector Machine (SVM) was used to decode activity on a trial-by-trial basis. Classification accuracy in each decoding run was calculated using a 5-fold cross-validation. Prior to decoding, a grid search procedure was used on each train set to estimate the optimal SVM hyper-parameters, using a 'nested' 5-fold cross-validation.

Although only a small number of features was available for decoding in each session (2-4 simultaneously recorded multi-units in each area), readout performance was significantly above chance in 97% of sessions in FEF and in 88% in V4. Average performance across sessions was higher in the FEF compared to V4 in agreement with the notion that the FEF is mainly responsible for shifts of attention. Interestingly, combining signals from the two areas improved performance only slightly. Merging signals from different sessions resulted in impressively high performance (FEF 99%, V4 96%). These results provide a quantitative account of how efficiently the allocation of spatial attention can be read out on a single-trial basis from FEF and V4. Moreover, they indicate that successful decoding of covert attention using simultaneously recorded signals from a single session is possible even with a limited number of features. Thus, they could allow for real time decoding of mental states. Although combining signals from FEF and V4 did not significantly improve performance, future studies should address whether the combination of signals from other areas in the attentional network may be more informative for decoding purposes.

Acknowledgments

EU FP7 Grant PIRG05-GA-2009-24676. PS was supported by the Action «Supporting Postdoctoral Researchers» of the GSRT (co-financed by the ESF and the Greek State)