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Detection of single trial power coincidence for the identification of distributed cortical processes in a behavioral context

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The analysis of neuronal processes distributed across multiple cortical areas aims at the identification of interactions between signals recorded at different sites. Such interactions can be described by measuring the stability of phase angles in the case of oscillatory signals or other forms of signal dependencies for less regular signals. Before, however, any form of interaction can be analyzed at a given time and frequency, it is necessary to assess whether all potentially contributing signals are present.

We have developed a new statistical procedure for the detection of coincident power in multiple simultaneously recorded analog signals, allowing the classification of events as 'non-accidental co-activation'. This method can effectively operate on single trials, each lasting only for a few seconds. Signals need to be transformed into time-frequency space, e.g. by applying a short-time Fourier transformation using a Gaussian window. The discrete wavelet transform (DWT) is used in order to weight the resulting power patterns according to their frequency. Subsequently, the weighted power patterns are binarized via applying a threshold. At this final stage, significant power coincidence is determined across all subgroups of channel combinations for individual frequencies by selecting the maximum ratio between observed and expected duration of co-activation as test statistic. The null hypothesis that the activity in each channel is independent from the activity in every other channel is simulated by independent, random rotation of the respective activity patterns.

We applied this procedure to single trials of multiple simultaneously sampled local field potentials (LFPs) obtained from occipital, parietal, central and precentral areas of three macaque monkeys. Since their task was to use visual cues to perform a precise arm movement, co-activation of numerous cortical sites was expected. In a data set with 17 channels analyzed, up to 13 sites expressed simultaneous power in the range between 5 and 240 Hz. On average, more than 50% of active channels participated at least once in a significant power co-activation pattern (PCP). Because the significance of such PCPs can be evaluated at the level of single trials, we are confident that this procedure is useful to study single trial variability with sufficient accuracy that much of the behavioral variability can be explained by the dynamics of the underlying distributed neuronal processes.