# SPATIAL FILTERING APPLIED TO EEG AND MEG DATA: APPLICATION AND STATISTICS

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Oscillatory brain activity has in recent years received strong interest. Brain oscillations are easily measured from humans using EEG or MEG. The strength of the brain oscillations are often several fold higher than event-related potentials/fields. Since brain oscillations are produced by large populations of neurons oscillating in synchrony they are bound to play an important role in neuronal computation. Dipole modeling applied to identify the source of oscillatory activity is often complicated by the fact that brain oscillations are not phase-locked to the events of the tasks in a given paradigm. Spatial filtering based on the covariance matrix ("beam-forming") has proven suitable for identifying oscillatory sources. I will here outline some of the practical aspect and problems associated with source reconstruction of oscillatory brain activity when using spatial filtering.

Consider a paradigm involving multiple trials recorded in response to various stimuli. These stimuli modulate the oscillatory brain activity in specific frequency bands. When applying spatial filtering to reconstruct the sources of the oscillatory modulation it is advantageous to identify the frequency bands and time-windows in which the modulation of interest occurs. This can be achieved by calculating the time-frequency representations (TFRs) of the signals at the sensors level. The TFRs can be estimated by wavelet or FFT-methods. This is among others important since the peak frequency of a given rhythm often varies from subject to subject. This should be taken into account when applying the spatial filtering approach. Furthermore, TFRs are useful for identifying the regions of interest by constructing topographical plots of the power in a given time-frequency window. The topographical plots are important for assessing the validity of the subsequent source reconstruction. When working with MEG data, the topographic plots are most informative when calculated from the planar gradient. When applying the planar gradient the maximal power is typically observed in the sensors directly above the source. When using MEG systems with axial gradiometers or magnetometers it is therefore advisable to transform the data to the planar gradient.

The time-windows and frequency bands identified from the TFRs can be used to determine the bandpass filter and data cutting applied to the signals prior to calculating the covariance matrix. Subsequently the spatial filter is applied. Source reconstruction is done by subdividing the brain volume into voxels and estimating the power for each voxel. This technique allows a comparison of the source distributions for different conditions. However, due to the high number of voxels the statistical comparison between different conditions is complicated by the multiple comparisons (extreme inflation of the Type 1 statistical error if multiple voxel-specific statistical tests are performed). This problem has its parallel in fMRI/PET methodologies, and there it is usually solved by computing p-values for the maximum Z-statistic under the assumption of a zero-mean Gaussian random field. Gaussian random field theory is complicated by limited knowledge on spatial correlations. We propose to use an non-parametric approach in which clusters of significant power is identified by means of a randomization test.

In summary, spatial filtering provides a powerful tool for source construction of oscillatory brain activity. However, the application of spatial filtering can be improved by applying time-frequency representations in order to identify the optimal time window and frequency band to be applied. Additionally, sophisticated statistical procedures are required in order to estimate the reliability of the reconstructed sources.