Parametric empirical Bayes for spectral DCM
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Background: We have introduced a spectral scheme for resting state fMRI that extends the Dynamical Causal Modelling (DCM) framework to model neuronal fluctuations in addition to effective connectivity – known as spectral DCM. Recently, we also introduced a new framework based on Parametric Empirical Bayes (PEB) – a between-subjects model over parameters – which models how individual (within-subject) connections relate to group or condition means. This approach calls on Bayesian Model Reduction (BMR) to finesse the inversion of multiple models of a single dataset or a single (hierarchical) model of multiple datasets. We use these new procedures to demonstrate the analysis of a multisession fMRI study using spectral DCM.

Methods: We use simulated resting state fMRI data to establish the face validity of multisession data acquisition. The basic question addressed in this analysis is: are between session effects expressed in terms of connectivity or neuronal fluctuations? In this example, we simulated three sessions of 8 subjects each with 256 scans with a TR of 2 seconds. We analyzed these sessions with a monotonic change in the intrinsic (self) connectivity over sessions. This involved decreases in intrinsic (or self) connectivity at the first two nodes of a simple three node hierarchy – and an increase at the highest (third) level. Having inverted every session, we can construct a between session model at the second level. We were interested in identifying which parameters change according to the session-specific effects encoded in a second-level design matrix. Using BMR, we can then compared models with and without each parameter for the constant (first) and interesting (second) explanatory variables in the design matrix.

Results: The figure shows the results of second-level Bayesian model comparison in terms of Bayesian model averages of the second level parameters over three sessions. These averages are shown with the posterior means in grey and the 95% confidence intervals in pink. Black bars are the true values. Posterior densities are shown separately for the session means (left panels) and changes in intrinsic connectivity over sessions (right panels). The upper panels show the posterior estimates before Bayesian model reduction and the lower panels after reduction. The key thing to observe is that some parameters have been removed. We see that all three changes in intrinsic connectivity – that characterize session specific changes – have been correctly identified.

Conclusions: We present an extension of spectral DCM using Parametric Empirical Bayes to model multisession resting state fMRI data. Using simulated data, we provide face validity of this scheme and show that between session effects can be efficiently recovered using empirical Bayes and Bayesian model reduction.