Figure 1: Preprocessing and quality control

A) EEG/FMRI processing pipeline. Gradient/Ballistocardiogram artifacts were removed from EEG signals, noise components were removed using ICA, and clean channel-level signal were projected to source space using precise electrode locations obtained from ultra-short TE MRI image of EEG cap. FMRI underwent EPI correction, noise removal using ICA, and bandpass filtering (0.01-0.5Hz). BOLD signal was correlated with downsampled, bandpass filtered EEG power in different frequency bands, in each voxel.

B) EEG data quality control. To ensure good quality EEG alpha/beta and gamma response inside scanner, identical stimuli were presented outside scanner for comparison.

Figure 2: Canonical HRF analysis

A) EEG-BOLD coupling for different states and frequency bands. Correlating alpha/beta power with the canonical HRF and correlating with bold revealed negative correlations in the occipital lobe, while doing the same with gamma power revealed positive gamma-BOLD correlations.

B) examining the coupling spectrum in two specific regions (occipital lobe and DMN) reveals significant differences in alpha-BOLD coupling across regions.

C) examining the coupling spectrum in the same region but across two specific states (resting state and retinotopy) reveals differences in coupling depending on brain state.

Figure 3: Cross-correlation analysis

A) average time-frequency cross correlation across all brain states and areas. Strongest correlations are all below 30Hz.

B) time frequency cross correlation in a single brain area (visual cortex)

C) time frequency cross correlation in a single brain area (DMN)

D) alpha/beta coupling time-courses in visual cortex (canonical HRF shown for comparison) for two different brain states. Event-related alpha coupling shows oscillatory profile due to the stimulus presentation timing, but a clear negative peak at 6 seconds. Rest coupling peaks more slowly, at 9-10s following an alpha/beta desynchronization.

E) same as (D) but for DMN.

The BOLD signal is linked to neural activity through the canonical hemodynamic response function (HRF), often assumed to be static across both brain area and brain state. We employed simultaneous EEG-FMRI recordings to investigate the hemodynamic response to neural activity in the alpha, beta, and gamma frequency bands. We find that the shape of the HRF depends on both brain region, and brain state. DMN BOLD signals are linked alpha synchronization, while occipital BOLD signals are linked to alpha/beta desynchronization and gamma synchronization. Connectivity estimates assuming a canonical HRF may be biased by HRF differences across region and state.