The effects of bandpass filtering on resting state and task-based measures of functional connectivity

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Background: Correlations in low frequency oscillations during resting state fMRI are thought to reflect intrinsic connectivity in large-scale brain networks. Fluctuations in the BOLD signal are subtle, requiring noise-reducing preprocessing in order to increase the signal-to-noise ratio and more accurately detect underlying brain activity/connectivity. One preprocessing technique often employed is bandpass filtering, which eliminates temporal frequencies outside a specified range of interest, typically below ~0.01 Hz and above ~0.1 Hz (Fox et al., 2005; Murphy et al., 2013). Highpass filtering BOLD data is relatively uncontroversial since it removes low frequency drifts due to scanner noise and is standard in most fMRI preprocessing pipelines. However, low pass filtering has been shown to be problematic in that it decreases sensitivity to task-related activations without increasing specificity (Skudlarksi et al., 1999; Della Maggiore et al., 2002) and induces spurious autocorrelation in resting state studies (Davey et al., 2013). Furthermore, recent work suggests that large-scale brain network activity is not restricted to frequencies below 0.1 Hz (Niazy et al., 2011; Kalcher et al., 2014). This motivates a reevaluation of functional connectivity results that underwent bandpass filtering, particularly those that aim to investigate the significance of large-scale networks during tasks. The present study seeks to understand the effects of bandpass filtering on ROI-to-voxel functional connectivity at rest and during two tasks.

Methods: Data from resting state, a finger opposition task (blocked design) and a stop signal task (event-related design) were temporally preprocessed in two different ways, one using bandpass filtering (0.009 < f < 0.08) and one using highpass filtering (0.009 < f). Next, we extracted average signal from a set of 10mm spherical ROIs from default mode network and task positive network. Data were preprocessed in the Conn Toolbox, regressing out 6 motion parameters and their first order temporal derivatives as well as signal from white matter and CSF. We then compared ROI-to-voxel functional connectivity between highpass and bandpass groups during rest and task states.

Results: Our results show that bandpass filtering reduces connectivity from ROIs to brain regions typically considered outside the networks canonical topology. Highpass filtering on the other hand seems to reduce within network connectivity. This effect is most strongly observed in the event-related stop signal task. For example, during Go Trials in the stop signal task, PCC was shown to connect to supplementary motor area in the highpass group, however in the bandpass filtered group it showed greater connectivity with bilateral parahippocampal gyri.

Conclusions: These results demonstrate that functional connectivity measurements are significantly influenced by temporal filtering techniques used in preprocessing, and highlight the importance of including high frequency fluctuations when examining functional connectivity during task performance.