A Resting-State Connectivity Index With No Dependence on SNR and CNR

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Introduction

Resting-state fMRI analysis is often performed by averaging the time courses in seed and target ROIs and then computing the strength of connectivity using a form of temporal cross-correlation [1,2]. Alternatively, one can calculate the correlation between every voxel in the seed ROI and every voxel in the target ROI and then average all the correlation coefficients [3]. A good connectivity index should be sensitive to meaningful physiological changes in the seed and target (e.g. change in connectivity strength in response to a disease process), but remain insensitive to SNR and CNR, which can change between sessions. We introduce a resting-state connectivity index that is normalized to the connectivity of the seed to itself. This acts as a form of normalization of connectivity within the given data set, and hence should remove the dependence on changes in SNR and CNR.

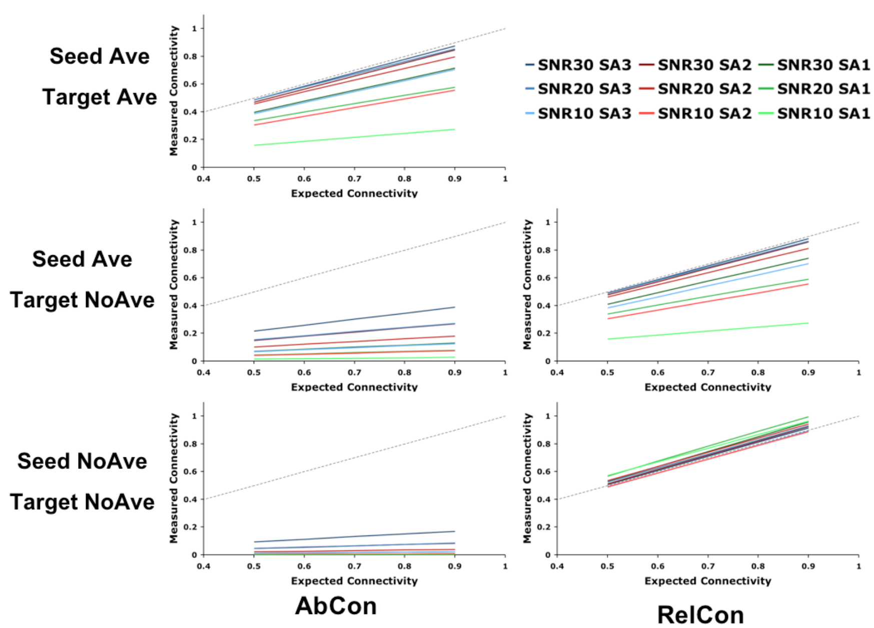
Method

We calculated resting-state connectivity between a seed and target using three methods, all of which are absolute measures of connectivity (AbCon): 1) average the signals in the seed and target ROIs and then calculate the correlation coefficient of the correlation between the two signals (Seed Ave, Target Ave); 2) average the signals in the seed ROI, calculate its correlation with each of the signals within the target ROI, and then average the correlation coefficients (Seed Ave, Target NoAve); 3) compute the correlation coefficient between each and every pair of seed and target ROI signals and average the Fisher correlation coefficients (Seed NoAve, Target NoAve). For 2) and 3), we also computed a relative connectivity (RelCon) by dividing each by the connectivity of the seed with itself as computed by 2) and 3). All correlation coefficients are Fisher transformed before averaging.

One fMRI volume (i.e., one time point) was extracted from a real dataset, and was duplicated to generate a 330-volume series, assuming TR = 1 sec. Rician distributed noise was added to create three datasets with SNR = 30, 20 and 10. A known reference signal was generated by combining sinusoid functions with frequencies between 0 to 0.1 Hz with random amplitude and phase. The generated signal was then added to the seed and target ROIs with signal amplitudes (SA) of 1, 2, or 3 percent of the average signal. 150 voxels in each of the left and right hemispheres were selected as ROIs. For each SNR and SA, 25 datasets were synthesized. Strength of connectivity between left and right ROIs was varied from 0.5 to 0.9 by shifting the signals of the right ROI by differing amounts of time.

Results:

Measured connectivity as a function of expected connectivity is plotted in the adjacent figure for each method of connectivity calculation. The dashed lines indicate lines of unity. The addition of noise reduces measured connectivity. Only the relative connectivity index for seed NoAve and target NoAve exhibit no dependence on SNR and SA.



Conclusion:

We have introduced a relative connectivity index that compensates for differences in SNR and CNR between datasets and sessions. In addition, there is less dependence on SNR and CNR for calculating the correlation for each voxel and then average the correlation coefficients compared to averaging signals and then calculating the correlation.

References:

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