The Effects of Time Length on Resting-state Functional Connectivity

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Introduction:

In recent years, the synchronized low-frequency fluctuations in resting-state fMRI have become an interesting tool for studying functional connectivity in the human brain (1). Theoretically, longer scan time may result in better connectivity maps, while practically the scan time is limited mainly due to subject tolerance inside the scanner. The objective of this study was to examine the effects of the length of resting-state scanning time on the results of functional connectivity, and find the best tradeoff between the quality of connectivity map and scanning time.

Materials and Methods:

Ten young normal control subjects were recruited in this study (Age 32.2±10.2 yrs). A consent form was obtained from each subject before scanning. **fMRI experiments:** The MRI scans were conducted at a GE 3T Signa LX scanner with an 8-channel birdcage RF head coil. SPGR anatomical images were acquired prior to functional scans. Two fMRI runs were performed for each subject, a 20-minute resting-state scan followed by 6-minute task scan (right-hand finger tapping), which served as guide to define the seed regions for functional connectivity analysis. During the resting-state scan, the subjects were asked to focus on the screen showing a red cross. Functional images were obtained by using single-shot EPI sequence (TE=27ms, TR=2000ms, slice thickness=4mm with 1mm spacing, Field of view=24cm, matrix size=64×64, 15 axial slices). **Data analysis:** The image data processing and statistical analysis were conducted with AFNI. For finger tapping datasets, after motion detection and volume registration, the magnitude of task-related activation in each voxel was calculated with a general linear model (GLM) using a boxcar function convolved with a canonical hemodynamic response. The maximum-activated voxel in left motor cortex and its 26 nearest neighbors were defined as seed ROI for the following functional connectivity analysis. The processing of 20-minute resting-state datasets included following steps. The first 5 time points of the total 600 time points were discarded in order to obtain a stable state. All data were motion corrected and volume registered, followed by third order time course detrending. After data pre-processing, the time series segments with different lengths (58, 108, 208, 408, 508 time points) were extracted from the 600-point time courses. Each segment was then low-pass filtered with cutoff frequencies of [0, 0.1] Hz. The first and last 4 points of each segment were dropped to avoid the cutoff effects during frequency filtering, leaving 50, 100, 200, 400, 500 points in segments. The maps of cross-correlation coefficients (CC) for different time course lengths were obtained by cross-correlating each voxel time course with the average time course of seed voxels. All CC maps were then converted to standard Talairach space. To determine the most significant voxels and compare them among groups, different thresholds were applied to CC maps to guarantee the same number of voxels (500 voxels in original resolution) would be left in maps for all subjects and all different lengths. The connectivity voxels were counted for different time series lengths as a percentage of the areas in both left and right side of precentral and postcentral gyrus.

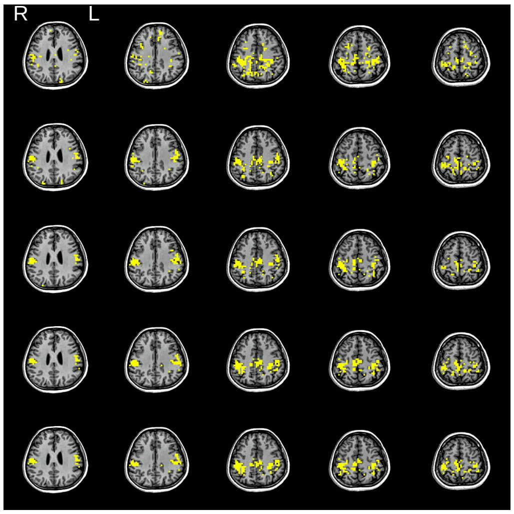

Figure 1. The connectivity maps seeded in left primary motor cortex. Each row presents connectivity map corresponding to different time series lengths (from top to bottom: 100, 200, 400, 800, 1000 sec, respectively).

Results and Discussions:

Figure 1 shows the connectivity maps for one subject with different time series lengths. The connectivity patterns are very similar for time series lengths of 400, 800 and 1000 sec. In these maps, the majority of voxels correlated to seed ROI are located in the motor cortex, while the maps are less localized for the length of 100 or 200 sec. Statistically, as shown in figure 2, the groups with the length of 100 and 200 sec have significantly less percentages of connectivity voxels (52.5%, 63.4%) located inside the motor cortex, compared to other groups (72.5%, 77.9% and 78.5% for 400, 800, 1000 sec, respectively). The results suggest that in this fMRI experimental setting about 400 sec in scanning is long enough to provide accurate functional connectivity maps. However, besides time length, other time series properties, such as the SNR and magnetic field strength, may also significantly affect the connectivity maps (2).

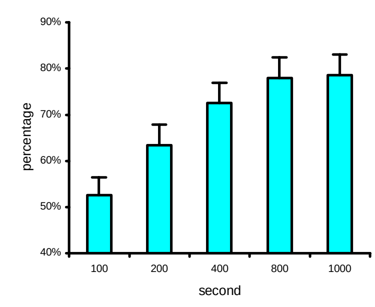

Figure 2. The effect of time length on functional connectivity. The FC is expressed as a percentage of connectivity voxels over the both-side motor cortex regions.

Reference

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2. Xu Y., Xu G., Wu G., Antuono P., Rowe D.B., Li S-J., The phase shift index for marking abnormal functional synchrony in Alzheimer's patients by fMRI. Magn. Reson. Imaging, 2007. in press

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