Prolonged tasks during steady state fMRI

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Introduction

In this study, the focus is on the stability and reliability of the measured brain activation during an extended period of stimulation. The motivation for this work is to test whether it is possible to differentiate between resting scans and other scans with tasks that reached a steady state (SS). For instance, a comparison between resting scans of the subject experiencing a chronic pain and when the subject is pain free. A long period of finger taps was used as a stimulus for the SS task in this study.

Methods

Resting state functional (r-fMRI) studies were acquired from one subject on five different days. During each study, two functional scans were acquired for the duration of 12 minutes each. The first acquired while the subject was at rest, the second acquired while the subject was finger tapping for the entire scan duration. The order of these two scans was alternated on different days. During the first day of scanning, the subject performed a 30 sec on/off finger tapping task for 210 sec. Then, this task was repeated with intervals increased to 3 minutes on/off. The images were acquired using a 3 T Achieva Philips scanner (Cleveland, OH), equipped with an 8-channel head coil. The functional EPI

Figure 1. The data selection windows of the analyzed time series with starting and time.

images were acquired with an isotropic spatial resolution of 3 mm, TR/TE 2000/30 ms, 80° flip angle, 80×80 matrix size, 35 slices. During each MRI session, a B0 field map as well as high resolution 3D T1 weighted images was acquired. The images were analyzed using FSL (FMRIB Software) and AFNI (NIMH/NIH) tools. The functional images were motion corrected, smoothed (5 mm^3) and band-pass filtered ($0.005<f<0.1$ Hz). The task based functional scans were analyzed and six voxels were selected as seeds for further analysis. For each scanning session, the entire 12 minutes of the functional scans were analyzed independently for the resting and SS acquisitions. To verify the consistency of the generated maps, the analysis was repeated seven times for each acquisition using a sliding window of six minute duration and skipping one minute successively as shown in Figure 1. The independent components (IC) and its mean were calculated using the dual regression approach [1]. Figure 2 shows the mean maps of ten ICs. In addition, seed maps were calculated from all time data windows.

Results

During the task based fMRI, the detectability of the functional response diminished when the task period increased from 30 sec to 3 minutes. Hence task based fMRI is not sensitive to an extended period of stimulation [3]. The similarity coefficient η^2 [2] was calculated to evaluate the correlation between the rest and SS maps. η^2 varies from 1 to 0 for similar to dissimilar maps respectively. Figure 3 shows η^2 for some of the evaluated maps from all the analyzed six minute data windows. Comparing the correlations between the rest and SS functional maps, a greater similarity can be seen for the maps of the same condition and lower similarity for the cross condition.

Conclusions

A clear distinction can be observed between the functional maps when the subject was at rest, and when finger tapping for six minutes or longer. It is, therefore, possible to quantify differences in functional responses of the subject when at rest and when being stimulated for an extended period of time. Consequently, it is possible to reliably detect spatial and dynamic functional activity in these studies.

References:

[1] Zuo X et al., NeuroImage 49 (2010) 2163-77. [2] Cohen AL et al., NeuroImage 41(2008) 45-57. [3] Birn et al., NeuroImage 15 (2002)252-64.
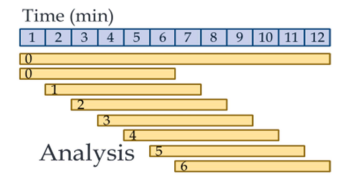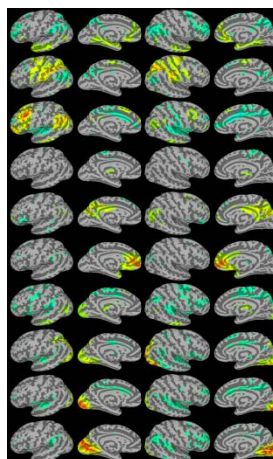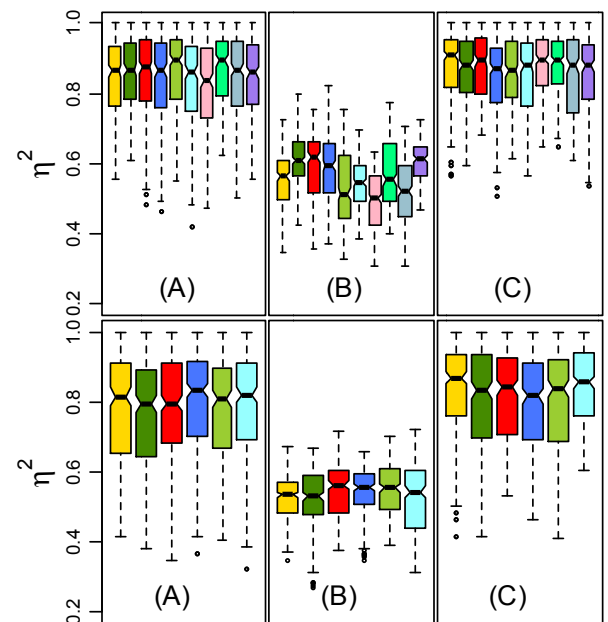
Figure 2. The mean of ten independent components.

Figure 3. Similarity coefficient from maps of ten ICs (uper) and six seeds (lower). (A,C) is the correlation between rest/rest and SS/SS respectively, while (B) is between rest and SS.