Prospective active marker motion correction improves statistical power in group fMRI

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Introduction

Head motion artifacts in functional MRI (fMRI) are a significant contributor to poor data quality. In this study, we propose the use of prospective active marker motion correction (PRAMMO) to increase statistical significance over standard retrospective correction techniques in three well-established fMRI experiments.

Methods

Imaging was performed with a standard quadrature bird-cage coil, and tracking via active-marker headband. A more detailed description of the real-time tracking system has been described in references (1)(2). Slice-by-slice real-time correction was applied to an axial, single-shot two-dimensional-EPI time series (TE/TR = 40/1680 ms, FA= 80°, FOV=220 x 220 mm, voxel size =3 x 3 mm, thickness/gap= 5/1 mm, slices=13, effective TR=2.3secs). A single dynamic EPI scan with 25 slices was acquired to help in registration along with a T1-weighted structural 3D-MPRAGE(TE/TR/TI/shot interval= 4 ms/ 8.3 ms/1000 ms/1500 ms, FA= 8°, FOV=240x240x150 mm, voxel size = 1.25 x 1.25 x 2 mm, slices = 125, ETL =48).

Flickering checkerboard, face localizer, and finger tapping block design fMRI paradigms were used to assess the performance of the active marker system. In each experiment, 2 trials of real-time correction “on” and 2 trials of real-time correction “off” were acquired. The volunteer was asked to remain motionless for all scans. Standard GLM analysis was performed in FMRIB Software Library (3). PRAMMO "off" scans were sent through three separate analysis pipelines: 1) retrospectively motion corrected using MCFLIRT with motion estimates added to the GLM as a confound, 2) retrospectively motion corrected using SPM REALIGN(4) with motion estimates added to the GLM as a confound, and 3) no motion correction, however, motion confounds from the active markers were added to the GLM. Retrospective motion correction was not applied to PRAMMO "on" scans.

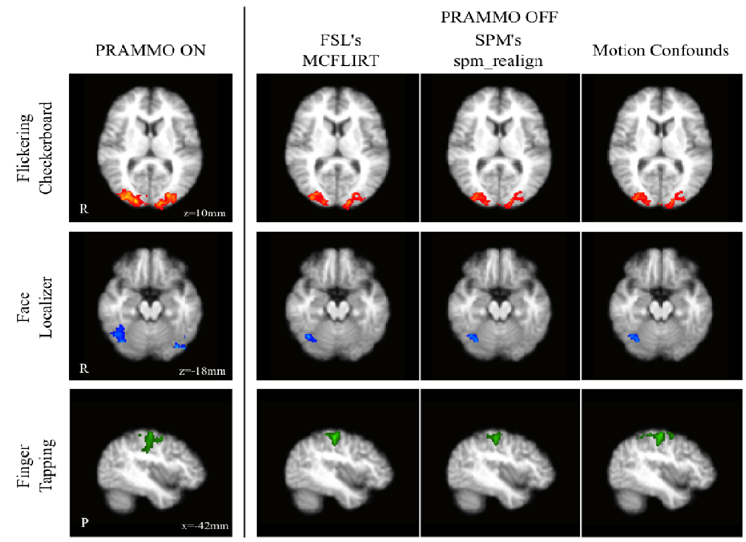

Figure 1 *Images show the statistical Z-score maps for the fMRI group analysis (n=6) of each motion correction technique (columns) applied to all 3 experimental paradigms(rows). Statistical maps are cluster thresholded by Z>2.3 and cluster significance P<.05. All color maps are ranged from Z=2.3-4.*

Results

Brain regions that passed the cluster threshold in the group level analysis for each experimental paradigm and motion correction technique are displayed in Fig. 1. The columns represent different motion correction techniques, while the rows are the different experimental paradigms. The locations of activation are consistent across techniques and appear in the expected regions for each paradigm: large activations in the occipital lobe and visual cortex for FC, predominately right-sided Fusiform Face Area (FFA) and Lateral Occipital Cortex (LOC) for FL, and left primary motor cortex for FT. Data corrected with PRAMMO consistently has larger cluster sizes and maximum z- scores than all the other motion correction methods. Group cluster sizes for each method are presented in Fig 2.

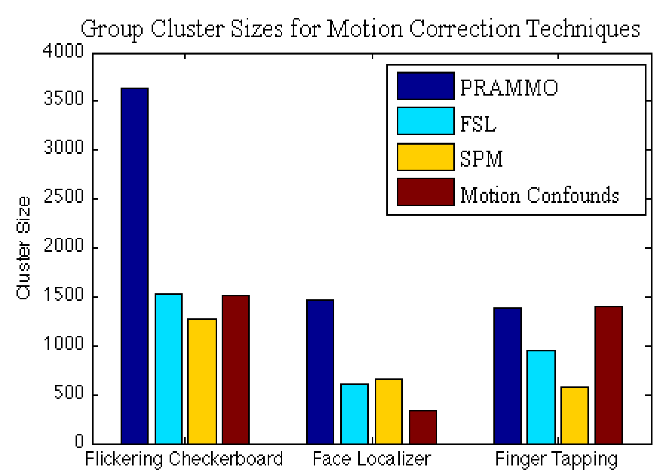

Figure 2 *Quantitative analysis of group level cluster sizes for each motion correction technique*

Conclusions

This study shows that our method of prospective real time realignment applied to standard fMRI acquisition significantly improves fMRI data quality prior to its statistical analysis and thus results in superior statistical power relative to the more commonly used retrospective methods.

References: [1] Ooi,MRM,2009 [2] Ooi,MRM,2011 [3] Smith, Neuroimage,2004 [4] Friston,HBM,1995