Inter-vender and Inter-session Reliability of Resting State Functional Magnetic Resonance Imaging (rsfMRI): Implications for Multicenter Studies

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Introduction:
Resting state functional magnetic resonance imaging (rsfMRI) studies have been increasingly used as a potential biomarker for validation of therapeutic efficacy and disease progression in clinical trials of neurologic disease, such as Alzheimer's disease[1]. Because of the potential to increase the number of subjects enrolled and to increase diversity of the subject population, multi-center studies are becoming popular. In order to conduct multicenter imaging study using rsfMRI, the test results should not be exposed by undesirable inter-vender or inter-site variability of data. However, available evidence on the reliability of RS-fMRI is limited[2,3]. The aim of this study was to evaluate inter-vender reliability and inter-session reliability of rsfMRI by using temporal signal-to-noise ratio (tSNR) and connectivity of default-mode network (DMN).

Materials and Methods:
Ten healthy subjects participated in this study (5 women and 5 men, aged 25 to 33). Each subject was scanned on three 3T MR scanners (GE Signa HDx, Siemens Skyra, and Philips Achieva) on two occasions. Parameters of rsfMRI for Philips and Siemens are as follows: TR/TE 2000/30, 240mm FOV, number of dynamics 180, flip angle 90, matrix 80x80, voxel size 3x3x4.5mm. For GE scanner, matrix size and voxel size were 64x64 and 3.75x3.75x4.5mm due to sequence constraint. All image processing was performed using SPM8 and in-house software based on MATLAB. For all blood-oxygen level dependent (BOLD) data, the first four volumes were discarded and the remaining volumes were preprocessed including realignment, spatial normalization and smoothing. First, temporal signal-to-noise ratio (tSNR) was calculated from the time course data after BOLD data were preprocessed in the predefined ROIs of DMN template. Inter-vender and inter-session reliabilities were assessed with the intra-class correlation coefficients (ICC) derived from variant components analysis. Second, independent component analysis (ICA) was performed to identify the connectivity of DMN by using GIFT toolbox. Two-tailed paired-t test was performed to compare the Z-maps of the DMN between two sessions and among different vendor groups.

RESULTS:
Temporal SNR for DMN was not significantly different among GE, Philips and Siemens scanner (302.31± 46.50 versus 254.59 ±77.00 versus 285.58 ± 83.87, p=0.638, Friedman test). The ICC for inter-vender reliability was good (ICC = 0.853; 95% CI, 0.650~0.957; p <0.001).Regarding the intra-vender reliability, GE scanner with a larger voxel size showed excellent correlation (ICC = 0.961; 95% confidence interval [CI], 0.687 ~ 0.981; p <0.001) while Philips (ICC = 0.671; 95% CI, -0.105~ 0.914; p = 0.032) and Siemens (ICC = 0.726; 95% CI, -0.215~0.933: p = 0.042) scanners showed relatively good correlation. The DMN pattern of subjects from three venders showed similar regions of functional connectivity (Fig.1). However, there are some inter-vender and inter-session differences in connectivity of the DMN (Fig. 2).

Discussion and Conclusion:
Although tSNR of rsfMRI was relatively good-to-excellent on three different 3-T MRI (from three different venders) on two different occasions, some inter-vender and inter-session differences in connectivity of the DMN were observed. Therefore, researchers using rsfMRI should be aware of these limitations especially in case of longitudinally designed multicenter studies.

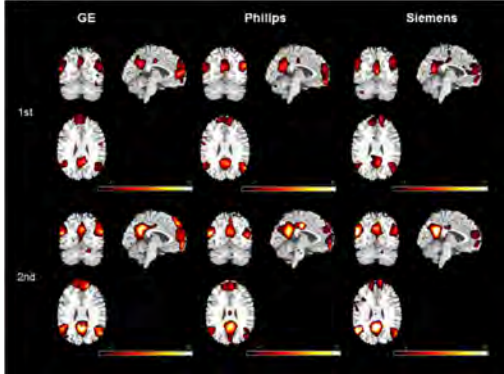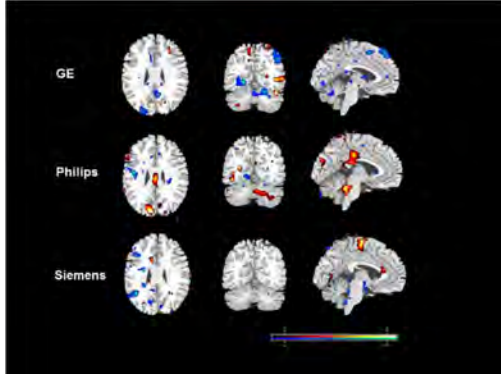Figure 1.   Figure 2.

Figure 1. Cortical representation of DMN obtained with the ICA method from different MR scanners in healthy subjects. The color scale represents T values. Figure 2. Differences in connectivity of the DMN between 1st and 2nd session in three vender groups.

References:
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