# Transition-band SSFP fMRI with Increased Spatial Coverage: Slice-dependent Frequency Adjustments in a Bilateral Motor Activation Experiment

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## Introduction

Transition-band balanced steady-state free precession (SSFP) fMRI with small flip angle excitation has been reported to be suitable for detecting small functional changes in blood oxygenation, with unique advantages of no geometric distortions and higher sensitivity compared with EPI fMRI [1, 2]. However, the native sensitivity to field heterogeneity limits its spatial coverage. Previous studies have already proposed to solve the problem of temporal field instability during consecutive scans of SSFP fMRI [3, 4]. Preliminary investigation to overcome spatial field heterogeneity, on the other hand, has only been addressed for visual fMRI with limited spatial coverage [5]. In bilateral motor fMRI, the functional activation areas in the two cerebral hemispheres are far apart from each other, implying more severe spatial field inhomogeneity in the regions of interest. In this study, we demonstrate successful applications of the slice-dependent frequency adjustment technique to compensate for off-resonance in motor fMRI experiments.

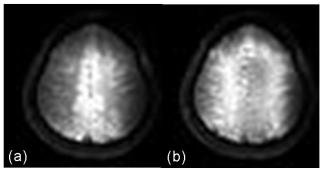


**Fig. 1** Original SSFP images without (a) and with (b) frequency adjustments.

## Methods

Imaging was performed on a 3.0T Philips Achieva system using an 8-channel head coil. Shimming was targeted on the region of primary motor cortex. The image parameters were 220 mm FOV, 64 by 64 matrix size, 4 mm slice thickness, 4° flip angle, and TR/TE = 8/4 ms. IIR-filtered frequecy stabilization was applied to compensate for temporal frequency drifts [4]. Two sets of SSFP fMRI images were acquired to compare conditions without and with slice frequency adjustments. The stimulus was a bilateral finger tapping task in 3on/4off blocks. Analysis was performed using T-test in SPM5.

To measure the regional off resonance frequency, a sweep scan (SSFP angles from -180 to 180 degrees with 10 degree increment, total 37 frames, TR/TE/flip angle: 8ms/4ms/5°) was applied with varying SSFP angle, which was inserted before fMRI experiments positioned exactly the same as in SSFP fMRI. Data from the sweep scan were used to determine the amount of frequency adjustments for each slice.

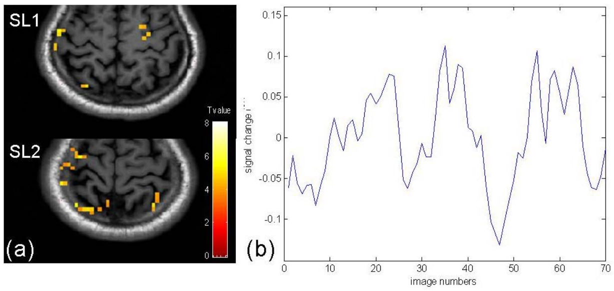


**Fig. 2** SSFP fMRI without slice frequency adjustment. (a) activation maps (b) the percentage of signal change

## Results

Figure 1 shows the first slice of the 35$^{th}$ dynamic of SSFP images from 70 dynamic scans of fMRI trails without and with slice frequency adjustments, respectively. The SSFP bright bands were better focused on the motor cortex in Fig.1(b) compared with Fig.1(a), indicating effective adjustments of the sensitive region in transition-band SSFP fMRI. Fig.2(a) shows the activation maps for the motor fMRI without slice-dependent frequency adjustment and Fig.2(b) is the temporal time curve displayed in the percentage of the SSFP fMRI signal change. Fig.3(a) shows the activation maps for the motor fMRI with frequency adjustment and Fig.3(b) is also the percentage of the SSFP fMRI signal change. According to the results, the activation voxels of the fMRI data with frequency adjustment were also more focused on the right region, namely the primary motor cortex. The functional signal intensity in Fig.3(b) also showed larger changes after slice-dependent frequency adjustments as compared with Fig.2(b).

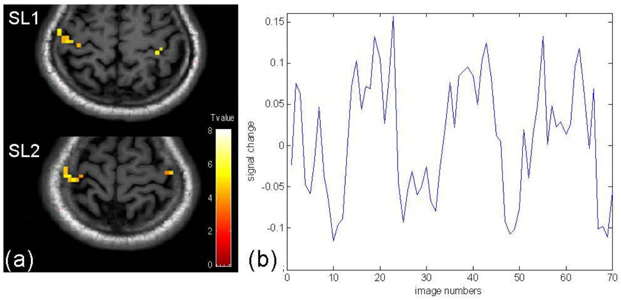


**Fig. 3** SSFP fMRI with slice frequency adjustment. (a) activation maps (b) the percentage of signal change. Note particularly the improved localization on the primary motor cortex and the increased functional sensitivity compared with Fig.2.

## Discussion and Conclusion

In transition-band SSFP fMRI, any slight field inhomogeneity may result in sub-optimized functional mapping results because of the narrow sensitivity band. For the primary motor cortex, the wide range of spatial coverage needed for the two hemispheric regions becomes a major obstable for transition-band SSFP fMRI. In this study, we have shown that the slice-dependent frequency adjustment was capable of overcoming the spatial coverage limitation of SSFP, such that bilateral motor fMRI yielded accurate results at increased functional sensitivity. Results from this study suggest that SSFP fMRI with frequency adjustments have potential for fMRI at high spatial resolution. Applications such as delineation of activation areas corresponding to different fingers are therefore possible.

## References

[1] Miller, K.L., et al., MRM, 2003. 50(4): p. 675.
[2] Miller, K.L., et al. MRM, 2006. 55: p. 161
[3] Lee, J., et al., MRM, 2006. 55(5): p. 1197.
[4] Wu, M.L., et al., MRM, 2007. 57(2): p. 369.
[5] Wu, M.L., et al. in ISMRM. 2007.