Local B_0-shift correction for 3D EPSI of human brain at 1.5 and 4 Tesla

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Introduction

Previously, high spatial resolution acquisition 3D echo-planar spectroscopic imaging (EPSI) in combination with a water reference EPSI data set was proposed to accomplish local frequency shift correction in human brain metabolite maps at 1.5T, minimizing inhomogeneous spectral line-broadening [1]. At higher magnetic field strength, increased magnetic field inhomogeneities typically lead to increased line-broadening. Additionally, increased susceptibility makes shimming of the main magnetic field over the whole head more difficult. The question therefore arises whether local frequency shift correction still helps limit line-broadening in human brain 3D EPSI at higher magnetic fields. In this study, the combination of high spatial resolution acquisition and local frequency shift correction to limit line-broadening is compared between 1.5 T and 4 T.

Methods

The data acquisition and processing strategies employed at 1.5 T (Siemens Magnetom Vision) and 4 T (Bruker MedSpec) have been described previously ([1] and [2], respectively). High spatial resolution EPSI data were taken from three volunteer studies at TE=25 ms (n=1) and 135 ms (n=2) at 1.5 T, and at TE=30 ms, 45 ms, and 70 ms (n=1 each) at 4 T. Acquisition parameters were TR/TI=1685/210 ms, FOV=280x280x180 mm^3 (x,y,z), and matrix size=48x48x18x512 (x,y,z,time) at 1.5 T, and TR/TI=1780/280 ms, FOV=280x280x180 mm^3, and matrix size=50x50x18x800 at 4 T. After reconstruction, including spatial smoothing, the effective voxel size was approximately 2 mL. The field map was derived from the water reference data acquired either sequentially (1.5 T) or interleaved (4 T) with the metabolite acquisition. The data was processed once with and once without the correction for local frequency shifts. Data were fitted using an automated spectral analysis procedure [3]. Quality maps showing voxels with acceptable spectral quality, i.e. with fitted metabolite linewidth between 3 Hz and 8 Hz (1.5 T), or 3 Hz and 21.3 Hz (4 T), were calculated [1], and the number of acceptable voxels compared for data reconstructed with and without frequency shift correction.

Results and Discussion

In Fig. 1 quality maps show accepted brain voxels (in white), and rejected voxels (in black) in one volunteer at 1.5 T (a,b; TE=135 ms) and in another volunteer at 4 T (c,d; TE=45 ms). In table 1, results for all volunteers are summarized. While acceptance rates depend on the definition of the brain mask used for fitting, the ratio of acceptance rates with versus without frequency shift correction reflects the success of the correction in reducing metabolite linewidth. Results are comparable for all subjects at both field strengths and at all echo times. Differences may be attributed to variability in shim quality. In particular at higher field, shimming of the main magnetic field over the entire head becomes increasingly difficult.

Conclusions

The results of this study are in good agreement with the report by Li et al. [4] that field homogeneity across voxels (expressed by T_2*) tends to increase as voxel size decreases with higher spatial resolution, leading to narrower metabolite peaks. While Li et al. showed results for 4 T only using 3D MRSI localized well within the brain, the present study demonstrates the validity of this argument for whole brain MRSI at 4 T as well as 1.5 T. In summary, high spatial resolution acquisition for 3D EPSI with correction of local frequency shifts is just as effective at 4 T as it is at 1.5 T. The findings further imply that it is advantageous to acquire spectroscopic imaging data at high resolution irrespective of SNR and recover signal retrospectively by spatial smoothing after establishing coherence by local frequency shift correction. Recovery of SNR was demonstrated previously [1].

References [1] Ebel A, et al. Magn. Reson. Imaging 21:113 (2003). [2] Ebel A, et al. Magn. Reson. Med. 54:697 (2005). [3] Soher BJ, et al. Magn. Reson. Med. 40:822 (1998). [4] Li BS, et al. Magn. Reson. Med. 46:1049 (2001).

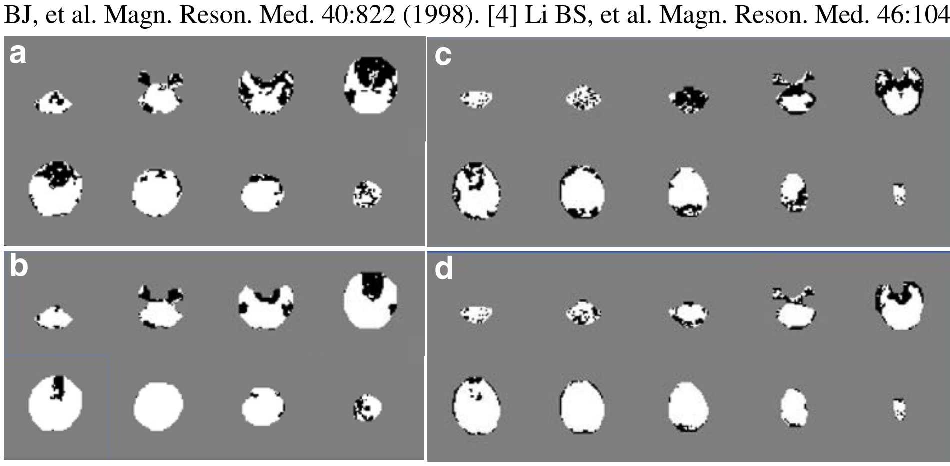

Figure 1: Maps of accepted voxels (white) and rejected voxels (black) at 1.5 T (a,b) and 4 T (c,d) without (a,c) and with correction of local frequency shifts (b,d).

Subject	TE [ms]	uncorrected	corrected	ratio
1	135	69.0	84.0	1.22
2	25	60.1	79.1	1.32
3	135	72.8	85.6	1.18

1.5T

Subject	TE [ms]	uncorrected	corrected	ratio
1	70	71.5	82.3	1.15
2	45	70.3	84.2	1.20
3	30	73.6	86.1	1.17

4T

Table 1: Whole-brain acceptance rates (in %) without and with correction of local frequency shifts at both field strengths. Ratios are for corrected versus uncorrected data.