Sensitivity Encoded Proton Echo Planar Spectroscopic Imaging (PEPSI) of Human Brain

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Introduction

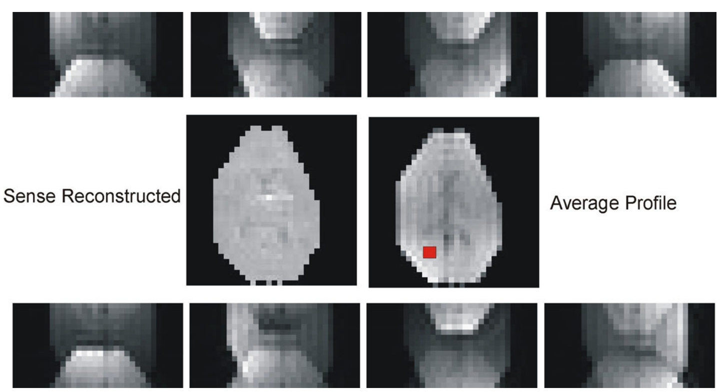
Parallel MRI techniques have been demonstrated to be capable of accelerating data acquisition by using spatial information from RF array coils to substitute for a portion of the data that would normally be acquired using sequentially-applied magnetic field gradients [1, 2]. This is particularly advantageous for spectroscopic imaging (SI) to reduce the long encoding times associated with phase encoding, as recently shown by Dydak et al. [3, 4]. Proton Echo Planar Spectroscopic Imaging (PEPSI) [5] provides much faster acceleration with a scan time of a minute for a 32x32 spatial matrix. However, 3D encoding is still time consuming. Furthermore, it is desirable to integrate phase cycling, which also elongates encoding times. Here, we report initial in-vivo results using a combination of parallel MRI and PEPSI to further accelerate the SI data acquisition.

Methods

Proton Echo Planar Spectroscopic Imaging (PEPSI) [5] was performed on healthy volunteers using 1.5 T Siemens Sonata and 3 T Siemens Trio scanners equipped with 8-channel surface array coils. PEPSI data were acquired from a para-axial slice at the upper edge of the ventricles with TR 2 s and short TE (12-30 ms), using 32x32 or 64x64 spatial matrix and minimum pixel size of 5 mm. Complete 8-slice outer volume suppression was applied along the perimeter of the brain. Even- and odd-echo data were reconstructed separately using a non-water suppressed reference scan for automatic phasing and frequency shift correction as described previously [5]. SENSE reconstructions were simulated by decimating k-space data along the phase encoding direction at 2.0, 2.67 and 4.0 acceleration rate. The coil sensitivity maps were estimated from the water spectral images using the non-water suppressed data for individual coil separately. Standard SENSE reconstruction algorithm [2] was implemented to unfold the individual aliased spectral images in one spatial dimension at 2.00, 2.67 and 4.00 fold accelerations. In the simulation, we also provide the full k-space acquisition as the prior information. Such prior was incorporated into the SENSE reconstruction using automatic regularization technique [6]. The regularization parameters were calculated from the water spectral images.

Results and Discussion

SENSE reconstruction was successful with 2-fold acceleration (Fig.1). Higher acceleration resulted in much increased noise level indicating unstable unfolding. Signal-to-noise with SENSE reconstruction decreased by approximately a square root of 2, as expected. Spectral quality and localization artifacts, such as lipid contamination, were similar to the original data (Fig.2).



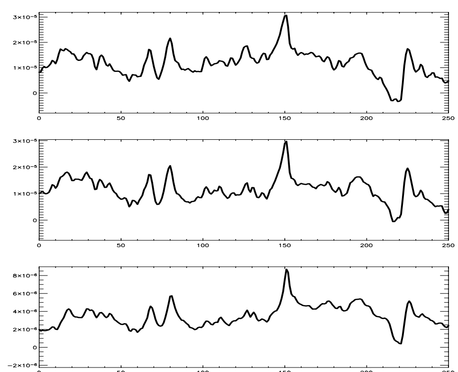


Fig.1 (left): The eight non-water suppressed images with aliasing correspond to an accelerating factor of 2. The left center image is obtained after SENSE reconstruction. For comparison purposes, the combined unaccelerated data are shown in the right center image.

Fig.2 (right) The displayed spectra from the water suppressed data are from voxel marked in red in Fig.1. The top spectrum was SENSE reconstructed with regularization, the middle spectra was SENSE reconstructed without regularization, and the bottom spectra is the weighted average spectra of the original 8 channel data without acceleration.

This work demonstrates the feasibility of combining SENSE and PEPSI for accelerated SI data acquisition. SNR decreases as a function of acceleration, as expected. On the other hand, for scan times of several minutes, which are typical for SI due to SNR limitations, it is now possible to perform 3D encoding and integrate phase cycling into PEPSI. Incorporation of prior information showed improved reconstructed spectra in our simulations. In the future, we expect to incorporate appropriate prior information, such as spectral models, to further stabilize the SENSE reconstruction. Such regularized reconstruction is expected to have higher SNR than the direct combination of SENSE and PEPSI techniques.

Acknowledgements

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