Sensitivity Encoded Proton Echo Planar Spectroscopic Imaging (SENSE-PEPSI) on Human Brain Using a Large-N Coil Array

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Introduction

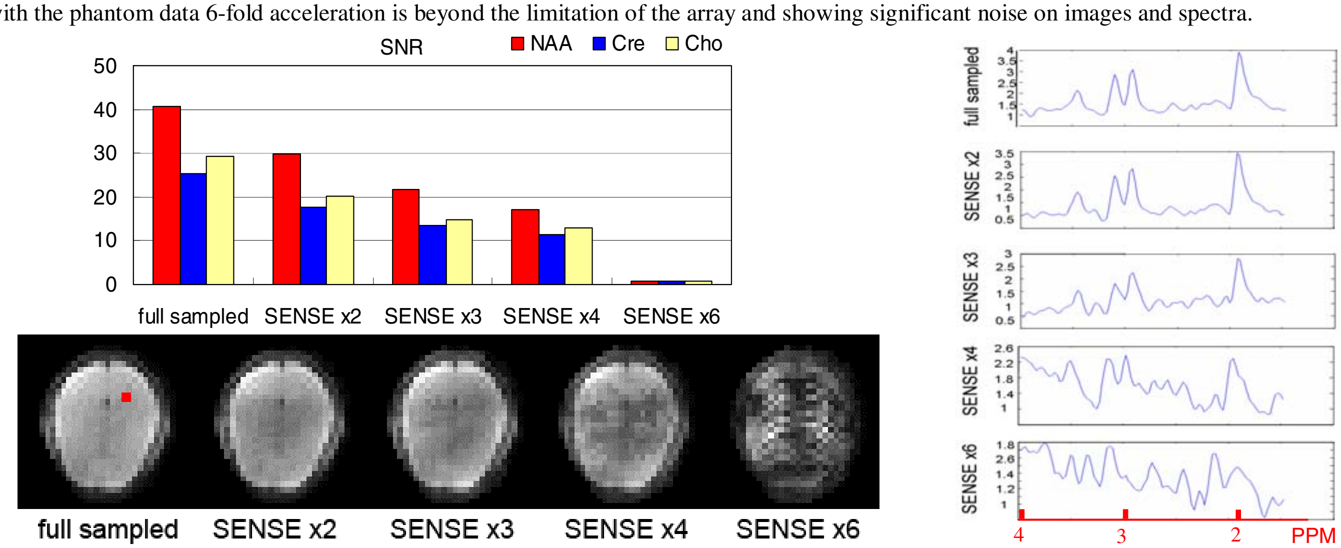
The combination of fast spatiospectral encoding using Proton-Echo-Planar-Spectroscopic-Imaging (PEPSI) [1] and sensitivity encoding with an RF coil array [2] has been demonstrated to achieve accelerated MR spectroscopic (MRSI) data acquisition at the cost of reduced SNR. Using a large-*N* coil array, the temporal resolution and SNR of the spectra from SENSE-PEPSI strategy are expected to be further improved due to the enhanced SNR from smaller RF coil elements in the array to tessellate the cortical coverage, as well as more spatially disparate information from different channels in the array. Here we report an *in vivo* experiment utilizing the 23-channel head RF coil array at 1.5T to investigate the feasibility of up to 6-fold acceleration along the phase encoding direction in a PEPSI experiment.

Methods

Proton-Echo-Planar-Spectroscopic-Imaging (PEPSI) [3] was performed on phantom and healthy volunteers using 1.5 T Siemens Avanto (SIEMENS Medical Solution, Erlangen, Germany). The 23-channel array was tiled from circular coils of 9.5-cm and 7.5-cm diameter using the combination of hexagonal and pentagonal symmetry with overlapping between nearest neighbors to minimize mutual inductance. Our previous study showed that, compared to traditional head coils, significant 3 - to 5-fold gains in SNR were obtained in the array, particularly in the cerebral cortex [4]. SENSE-PEPSI data were acquired from a para-axial slice at the upper edge of the ventricles with TR 2 s and short TE (20 ms), using 32x32 image matrix. 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 [3]. Total scan time was 64 second for the fully sampled data set. SENSE accelerated water-suppressed PEPSI data were acquired by decimating k-space data along the phase encoding direction to achieve 2.0-, 3.0-, 4.0- and 6.0-fold accelerations with imaging time of 32, 22, 16, and 11 seconds, respectively. The coil sensitivity maps were estimated from the water spectral images using the non-water suppressed (NWS) data for individual coil separately. Standard SENSE reconstruction algorithm [2] was implemented to unfold the individual aliased spectral images in one spatial dimension.

Results and Discussion

SENSE reconstruction on spectral phantom data was successful with 2-,3-, and 4-fold acceleration. Higher acceleration resulted in much increased noise level indicating unstable unfolding. The *in vivo* NWS data showed good reconstructed images up to 4-fold acceleration. In agreement with the phantom data 6-fold acceleration is beyond the limitation of the array and showing significant noise on images and spectra.



Top left: Metabolite SNR of choline (Cho), creatine (Cre) and N-acetyl-aspartate (NAA) from spectra in phantom. SNR decreases as higher acceleration. **Bottom left**: The *in vivo* non-water suppressed (NWS) projection image from 23channel. The combined un-accelerated data and SESNE reconstructed data of 2fold, 3fold, 4fold and 6fold are shown from left to right. **Right**: The displayed spectra from the *in vivo* water suppressed data are from a red marked voxel as depicted in the NWS projection image. Unfolding errors as a consequence of low SNR at 6-fold acceleration reduce the visibility of metabolite peaks.

This work demonstrates that the increase in the spatial information of the coil profiles and the increase in the SNR of individual RF coils of the 23-channel array can further accelerate the SENSE-PEPSI methods with acceptable reconstructed images and spectra. Even if averaging is still required to enhance SNR for 1.5T MRSI, the SENSE-PEPSI approach enables separate measurements to improve the motion immunity. We expect that using even larger-N array coils currently under development, such as 96-channel head array, can further increase the temporal resolution of high-speed MRSI, in particular for 3D spatial encoding.

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References

1. Posse, S., et al., Magn Reson Med, 1997. **37**(6): p. 858-65.
2. Pruessmann, K.P., et al., Magn Reson Med, 1999. **42**(5): p. 952-62.
3. Posse, S., et al., Magn Reson Med, 1995. **33**(1): p. 34-40.
4. Wiggins, G.C., et al.,in *ISMRM Thirteenth Scientific Meeting and Exhibition*. 2005.