Proton-Echo-Planar Spectroscopic Imaging (PEPSI) in Human Brain at 1.5, 3 and 4 Tesla

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Introduction:

The major factors limiting widespread use of proton spectroscopic imaging (*SI*) of the human brain are spatial resolution and measurement time (1). High speed spatial encoding schemes using echo-planar (2) and spiral methods (3) have been developed to monitor dynamic lactate changes (4) and to increase spatial resolution to minimize partial volume effects (5). Implementation of these methods at 3 and 4 Tesla is challenging due to gradient limitations. Here we implement short TE Proton-Echo-Planar-Spectroscopic-Imaging (*PEPSI*) with outer volume suppression on a new generation of 1.5, 3 and 4 Tesla scanners that share almost identical software and hardware platforms, in order to perform a performance comparison across field strengths.

Methods:

Measurements were performed on healthy volunteers using 1.5 Tesla Siemens Sonata, 3 Tesla Siemens Trio and 4 Tesla Bruker MedSpec scanners equipped with Sonata gradients and quadrature birdcage head coils. TR was 2 s and minimum TE was 30 ms. The *PEPSI* method (2) was implemented on the Siemens Syngo platform using 512 alternating readout gradients with 640 us duration. The corresponding spectral width after even/odd echo sorting (2) was 781 Hz. The spatial matrix was 32x32, 64x64 or 64x64x16 with 0.25 cm^3 minimum voxel size. Graphical volume pre-selection consisted of either (a) PRESS volume selection with complete 6 slice outer volume suppression or (b) excitation and double refocusing of a single para-axial slice/slab with 8 slice outer volume suppression along the perimeter of the brain. Fully-automated tuning included higher-order auto shimming based on 3D phase mapping and 3-pulse WET water suppression. Data were reconstructed offline, using a custom designed IDL software package with graphical user interface. Even and odd echo data were independently reconstructed (2) and combined in the frequency domain after automated phasing and frequency shift correction, based on a non-water-suppressed reference scan. Spectroscopic images were obtained by integration of the real data over a 0.1 ppm frequency width, after baseline correction.

Results:

Spectral quality of short TE PEPSI data was comparable to that obtained with conventional methods (Fig.1). The SNR of NAA at 4 T obtained in 4 minutes with 2 cc voxel size and TE 32 ms was 19:1, consistent with that of conventional PRESS SI. Very high spatial resolution (0.38 cc) data at 4 T and TE 85 ms were acquired in 32 minutes (Fig. 2). SNR of NAA was 14:1. The effect of B1-inhomogeneity at 4 T caused an intensity gradient in the metabolite maps. SNR at 4 T was 2.5 times larger than at 1.5 T and 1.4 times larger than at 3 T, consistent with an approximately linear SNR increase with field strength.

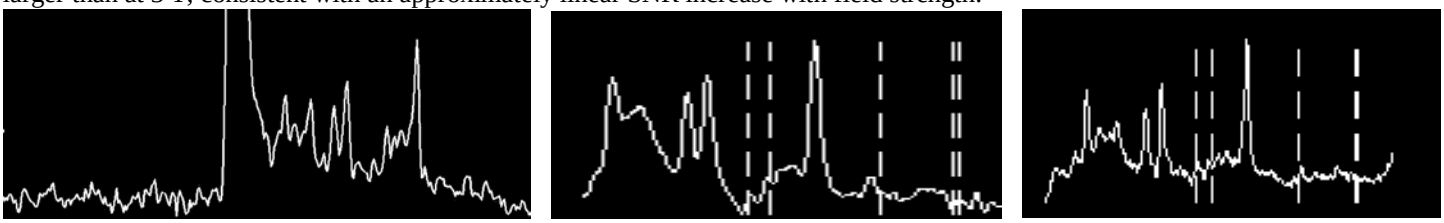

Fig.1: Examples of TE 32 ms spectra at 1.5, 3 and 4 Tesla

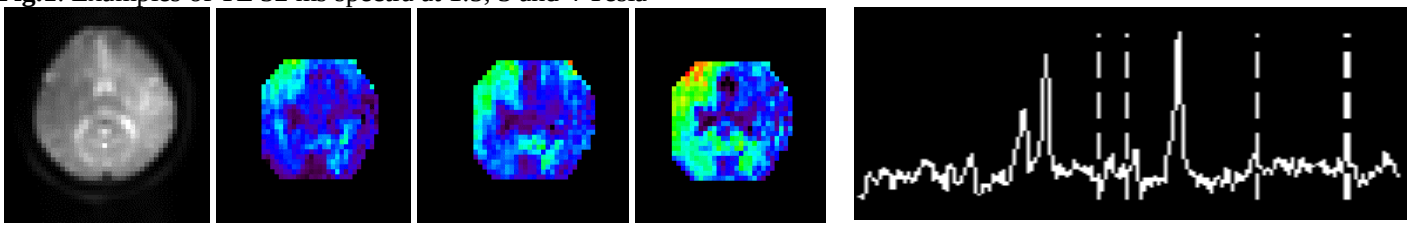

Fig.2: PEPSI at 4 Tesla with 64x64 matrix (0.38 cc): unsuppressed water - choline - creatine – NAA - single voxel spectrum

Discussion:

The implementation of PEPSI at 3 and 4 Tesla enables significant reduction in measurement time and unparalleled spatial resolution, taking advantage of the increase in SNR and spectral resolution with field strength. The performance of shorter readout gradients to increase the limited spectral bandwidth at 3 and 4 Tesla is under evaluation. Adaptation for 8-channel head array coil to further reduce scan time and improvement of outer volume suppression using our echo-dephasing methodology (5) are in progress.

Literature:

1. Nelson SJ, et al. NMR Biomed. 1997 Dec;10(8):411-22. 2. Posse S, et al. Radiology. 1994 Sep;192(3):733-8. 3. Adalsteinsson E, et al. Magn Reson Med. 1998 Jun;39(6):889-98. 4. Posse S, et al. Magn Reson Med. 1997 Jun;37(6):858-65. 5. Chu A, et al. Magn. Reson. Med. 2003, 49:817-821.

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