Selective homonuclear polarization transfer at 7T: single shot detection for GABA in human brain

J. W. Pan[1], N. Avdievich[1], and H. P. Hetherington[1]
[1]Yale University School of Medicine, New Haven, CT, United States

Introduction: Given its important role as the major inhibitory neurotransmitter, GABA is a well known target for detection in human brain. However, because of its overlap with many other resonances, editing is required for its unambiguous detection. The most commonly used approach to detect the C4 3.0ppm GABA resonance has been spectral editing, a two scan J-differencing method. We describe implementation of selective homonuclear polarization transfer to acquire GABA in a single shot in human brain. We do this at 7T in spectroscopic imaging format with 1.44cc resolution.

Methods: J-refocused coherence transfer is a double spin echo method known to enhance retention of signal from coupled spins. For an IS system, the first echo induces J modulation in the I magnetization to produce –2IxSz; the transfer (2^{nd}) 90_y pulse converts this → 2IzSx, which evolves into –Sy coherences in the second echo. If the I spin is suppressed prior to excitation, transfer is limited to those coherences starting from S and transferring into I. This method, selective homonuclear polarization transfer (SHPoT) has been suggested (1,2) but has not been implemented for GABA detection in human brain. Our implementation uses a J-refocus sequence with inclusion of T1 optimized inversion pre-pulses that suppress a bandwidth extending from water to include the C4 3.0ppm resonance of GABA (Fig. 1). As a result, creatine and choline are nulled, and any signal detected at 3.0ppm is due to coherence transfer from upfield resonances, i.e., from GABA at 1.9ppm and the coupled macromolecule (MM) at 1.6ppm. This sequence is implemented in a 10mM GABA phantom (also contains 0.5mM Magnevist, Fig. 2). At TE=1/4J (34ms) the J-refocus sequence refocuses J-modulation of coupled spins (Fig. 2A). To demonstrate the performance of the T1 optimized pre-pulse suppression, a double echo is shown (without J-refocusing, Fig. 2B). Combining J-refocusing with the pre-pulses suppression shows the transferred coherence at 3.0ppm (Fig. 2C). At TE=68ms, the C4 3.0ppm resonance is also present, however a loss of signal intensity compared to TE=34ms occurs (Fig. 2D). At 34ms, there is greater retention of the center line. In vivo, the shorter echo was used because of its narrower apparent linewidth, greater intensity and decreased T2 losses. To eliminate the MM component of the 3.0ppm resonance, a narrow band excitation pulse at 1.6ppm was added as a final pre-pulse.

A Varian DirectDrive head only 7T MR system with gradient head insert was used with a home built 8 element elliptical transceiver array as detector. For RF localization, two RF distributions (homogeneous, ring) was determined by B_1 mapping and optimization (3). Non-iterative shimming was performed using our previously described Bo mapping methods. Typical Bo shimming (entire slice) was ~10Hz for the centrum semiovale, 16x16 phase encoding was performed over a 192x192 FOV, TR 1.5s, TE34ms, 10mm slice (voxel size 1.44cc), 2averages, 13min acquisition.

Figure 1: SHPoT pulse sequence

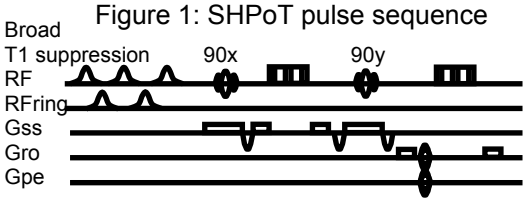


Figure 2: GABA phantom. A: J-refocused; B: double spin echo with pre-pulse suppression; C: SHPoT at TE 34ms; D: SHPoT at TE 68ms

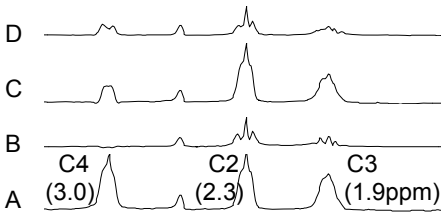
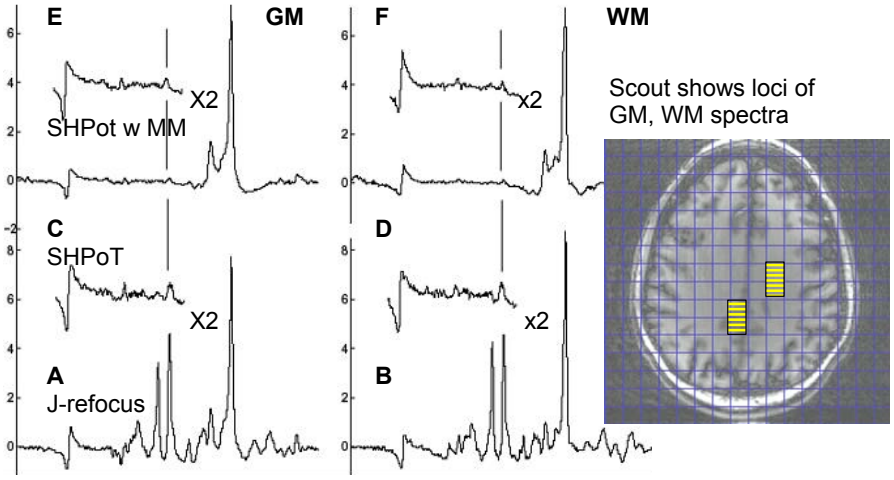


Figure 3: GABA detection in human brain: line indicates GABA 3.0ppm.



Results: Fig. 3 shows spectra (2 voxel sums) from the J-refocused acquisition (A,B), SHPoT without (C, D) and with MM suppression (E,F) in gray (A,C,E) and white matter (B,D,F). An advantage of this sequence is the simultaneous acquisition of NAA as a reference (similar concentrations between WM, GM). Using the amplitude ratios of GABA/NAA from the MM suppressed SHPoT acquisition yields GABA concentrations of ~1mM in gray and ~0.5mM in white matter.

Discussion: We have implemented a single shot acquisition of GABA in the human brain in spectroscopic imaging format. The ultra high field is very important in this sequence, for the SNR, water suppression and elimination of the overlapping MM resonance, based on a narrow band suppression pulse (±0.2ppm) at 1.6ppm.

Ref: (1) von Kienlin et al 1987; (2) Shen et al 2004; (3) Avdievich et al 2009