Improved Spectral Editing for Measurements of Cerebral GABA

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Introduction: Although spectral editing sequences using difference spectroscopy have been extensively used for the measurement of brain GABA, they are often criticized for their sensitivity to motion. Theoretical analysis of the sequence shows that the errors that are commonly attributed to motion, are often due to systematic correctable perturbations associated with the editing method itself. Since the phase and amplitude of the perturbation is directly dependent upon the amplitude of the editing pulse, correcting for this error is difficult when inhomogeneous RF coils are used for transmission. Unfortunately, the use of volume Tx/Rx head coils severely limits the sensitivity of the measurement. Thus, the goal of this work was to: 1) evaluate the phase error associated with GABA editing, 2) demonstrate its elimination using a homogeneous RF coil for transmission in conjunction with the calculated correction and 3) implement the sequence with phased arrays to acquire edited GABA data from the human occipital and temporal lobes.

Methods: Data were acquired on a Varian 4T Inova system using an actively detuneable Tx/Rx volume TEM ^{1}H coil with a receive only 4 coil phased array. To demonstrate the effectiveness of the sequence with homogeneous transmission and reception data was acquired using only the volume TEM. To improve the sensitivity of the volume coil study phased arrays were placed beneath the occipital lobe and lateral to the right temporal lobe. The data from the individual coils was phase corrected and summed using the weighting coefficients determined from the anatomical images. The editing sequences used a standard PRESS localization sequence with numerically optimized 90° and 180° pulses. Spectral editing of the GABA C-4 resonance (3.0ppm) was achieved by applying a selective inversion pulse (20ms gaussian pulse) alternately to the GABA C-3 resonance at 1.9ppm and at 1.5ppm (a position symmetric about the macromolecule resonance (MM) at 1.7ppm). The data was stored as two blocks and phase corrected using the calculated phase angle.

Results : Displayed in Fig. 1 is the frequency dependence of the inversion pulse (dotted line) and the phase (solid line) and amplitude (dashed line) of the perturbation caused by the editing pulse (Fig. 1A). Fig. 1B shows its partial cancellation when it is applied 0.4ppm away (symmetric to the macromolecule resonance). This cancels the change amplitude of the signal, however a significant phase error remains at the GABA position. Displayed in Fig 2 are GABA edited data acquired from a 48cc volume of the human occipital lobe using volume Tx/Rx. Fig. 2C and 2D (8x magnification) displays the difference spectrum (2B-2A) without phase correction. Note that the water resonance in the difference spectra is nearly completely cancelled (minimal perturbation at this position) indicating the degree of stability of the measurement. However, substantial intensity remains at the creatine position due to the much larger effect of the inversion pulse at this frequency. Fig. 2E and 2F show spectra after phase correction to eliminate the perturbation, providing a well-resolved GABA resonance free from MM contamination. To increase the SNR of the measurement we then acquired data with the phased array in the occipital lobe (12cc 16 min.) and a deeper location, the temporal lobe (24cc, 16 min.). Displayed in Figure 3 are data acquired from the human temporal lobe using a 24cc volume and 16 min of acquisition. Again a well-resolved GABA resonance is present in the phase corrected difference spectrum (3C).

Fig. 1

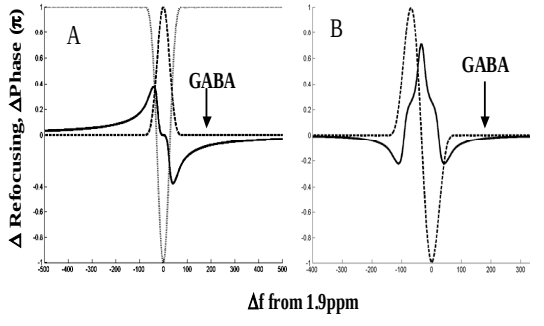


Fig. 2

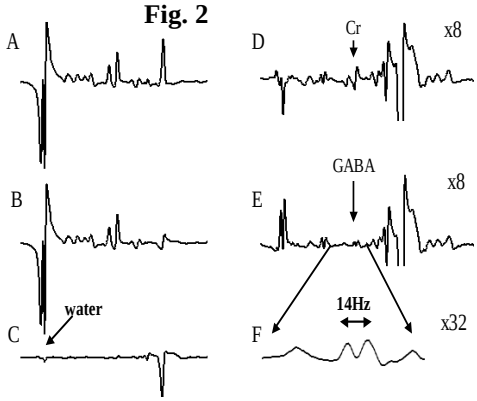
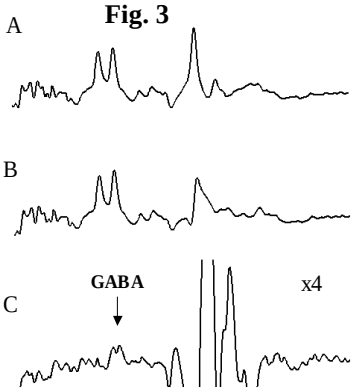


Fig. 3



Conclusions : Application of the editing pulse with a homogeneous transmission coil limits the required phase correction to a single well defined value, which when corrected for, provides well resolved GABA resonances free of creatine or MM contamination. The sensitivity of the measurement can then be regained using phased arrays for reception.