Multi-channel GABA editing on a clinical 3T scanner

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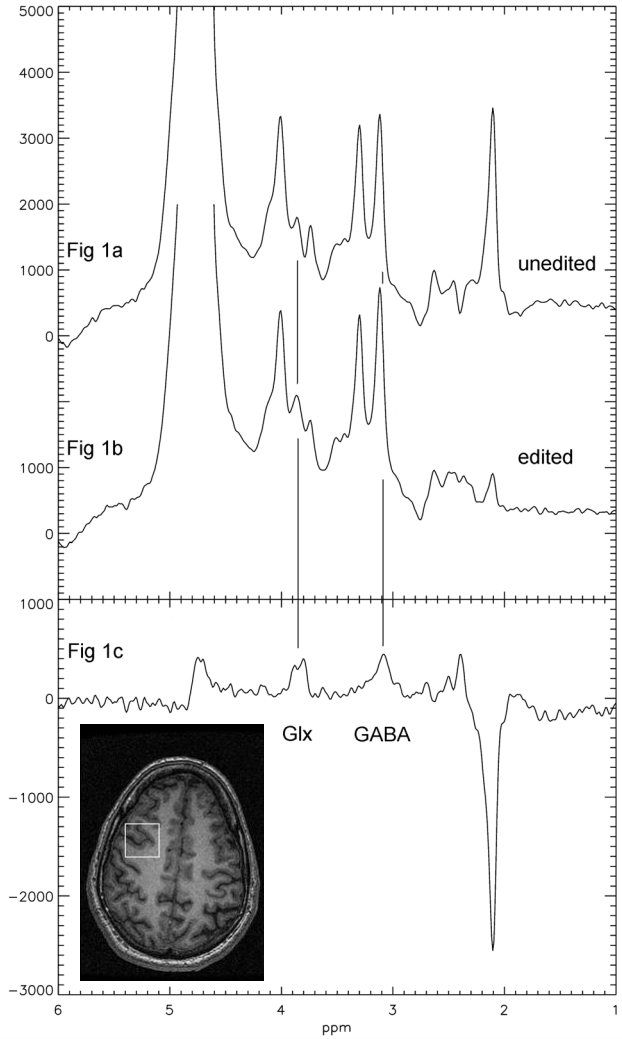
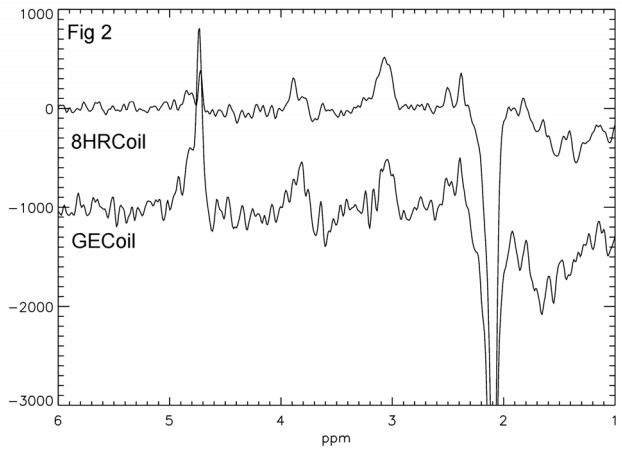
Introduction: GABA is the major inhibitory neurotransmitter believed to be involved in several psychiatric and neurological disorders. Measuring GABA levels in vivo is difficult because of two reasons: (i) the concentration of GABA is very low; and (ii) all GABA peaks are obscured by other, much stronger metabolite resonances at the field strength accessible for clinical studies. To separate GABA from the overlapping signals, several subtraction-based spectral editing techniques have been reported (1-4) with one of them implemented on a clinical 3T GE scanner (4). We have found that to achieve a useable SNR for GABA measurement long scanning time (~27 minutes for an 18 cc voxel) is necessary when using a volume head RF coil (5). Here we report significant improvement of SNR for GABA detection using an 8-channel coil on a widely available GE 3 Tesla Excite platform. To the best of our knowledge, this is the first demonstration of in vivo homonuclear spectral editing using a multi-channel RF system.

Methods and Results: All experiments were performed on a GE whole body scanner (GE, Milwaukee, WI) equipped with a body RF coil and running on the 3T Excite platform. A standard GE head coil (transmit/receive, 28-cm i.d.) and an 8-channel coil (23cm i.d. from MRI Devices, Waukesha WI, receive-only, RF transmission via the body RF coil) were used for detection. The data from the 8 channels were combined in the following way: First, a phase correction factor was calculated from water-unsuppressed reference data by taking the weighted average of the phase difference between a channel and channel 0. Each phase point was weighted with the corresponding absolute value of the water reference signal. The channels were then added together and phase corrected with an SNR-based weighting factor (6). The weighting factor of each channel was the absolute value of the first 512 points of the unsuppressed water signal summed and dived by the same sum of channel 0. The signal of the summed channels was then normalized by the sum of the individual channel weighting factors. No corrections for macromolecules were made.

The spectroscopy voxel (3 x 3 x 2 cm^3) was placed in the anterior left frontal lobe (Fig 1c). For GABA editing, TR/TE = 1500/68 ms. The GABA editing pulse sequence was modified from a standard PRESS sequence (4). The left shoulder of the GABA editing pulse (14.4 ms, B_{1max} = 160 Hz) was placed on GABA-3 at 1.91 ppm with the bandwidth approximately ranging from 2.2 ppm – 0.6 ppm. The GABA editing pulse was switched on and off during even- and odd-numbered scans, respectively. Fig. 1 shows the results of a 27 minute experiment (NS=1024) using the standard GE volume head coil. Fig 1a shows the summed spectrum from 512 odd-numbered scans at TE = 68 (Gaussian line broadening = 8 Hz). The corresponding spectrum summed from the even-numbered scans is displayed in Fig. 1b. The result of subtraction of Fig. 1a from Fig. 1b is shown in Fig. 1c. In Fig. 1c, the large NAA signal at 2.0 ppm was inverted due to the action of the editing pulse. The Glx-2 signal at 3.8 ppm and the Glx-4 signal at 2.4 ppm were also detected due to their J-coupling to Glx-3 at 2.1 ppm which is still in the frequency range of the editing pulse. The co-edited Glx-4 peak partially overlaps with the negative NAA signal. However, the Glx-2 signal at 3.8 ppm is cleanly co-edited, allowing simultaneous determination of Glx without GABA contamination. The edited GABA-4 signal is located at 3.0 ppm which is the target of GABA quantification. The co-edited GABA-2 signal at 2.3 ppm was overwhelmingly overlapped by the residual Glx-4 signal at 2.35 ppm and the dominant NAA signal at 2.0 ppm. Excellent water and outer volume suppression were also achieved. Fig. 2 shows the GABA signals from a 13 minute experiment (NS=512) with the standard GE head coil and the 8 channel MRI devices coil. The acquisition parameters for Fig 2 are (TR/TE = 1500/68 ms, 3 x 3 x 2 cm^3, NS = 512) and the same data processing parameters (Gaussian line broadening = 8 Hz) were used on the same subject and anatomical location. In comparison to Fig 1c obtained using the standard head coil and twice the acquisition time, GABA data obtained using the 8-channel coil (Fig 2) clearly shows significant improvement in SNR as expected.





Discussion: Multi-channel RF coils have found wide-spread applications in clinical imaging and proton spectroscopy. Here we extend the application of multi-channel coils to spectral editing techniques. As shown in Fig. 2, detection of dilute metabolites such as GABA can be greatly benefited from the additional SNR gains rendered by the multi-channel receive coils. Depending on the location of the voxel a SNR gain by a factor of two to three can be obtained by using the 8-channel coil. This allows for a substantial reduction in scanning time, which is critical for studying psychiatric patients who often have low tolerance of long scanning times.

References: 1) Rothman DL, et al, Proc Natl Acad Sci USA, 90 5662 (1993) 2) Mescher M. et al, NMR Biomed, 11, 266 (1998) 3) Hetherington HP, et al, MRM 39, 6 (1998), 4) Sailasuta P et al, Proc Intl Soc Mag Reson Med 9 p1011 (2001) 5) Hasler G. et al, Biol Psychiatry, submitted. 6) Jesmanowicz A et al, Proc SMRM p923 (1989).