

GABA editing at 3T with Macromolecule Suppression: MEGA-SPECIAL

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Introduction. One commonly used method for *in-vivo* magnetic resonance spectroscopy (MRS) detection of γ -aminobutyric acid (GABA) is the MEGA-PRESS technique [1], which enables direct observation of the GABA resonance at 3.02 ppm. Unfortunately, direct quantification of GABA using MEGA-PRESS is complicated by co-editing of macromolecule (MM) signals, which also resonate at 3.02 ppm [2]. Two methods have been suggested to separate GABA from MM. The first separates the two based on their unique T1 values using a metabolite suppressed inversion-recovery acquisition, resulting in a factor of two increase in scan time. The second method, proposed by Henry et al [3], is to apply the editing pulse symmetrically about the MM coupling partner in even and odd acquisitions. This approach ensures that the MM contribution is identical in even and odd acquisitions, and therefore any MM signal is subtracted out in the difference editing process. Previously, the Henry method has been successfully incorporated into the MEGA-PRESS scheme at 7 Tesla [4]. However, at 3T, due to reduced spectral dispersion, the editing pulse exhibits reduced frequency selectivity, making it impossible to use the Henry method in MEGA-PRESS. We present a new method for GABA editing at 3T with no MM contamination. This is achieved by combining the MEGA technique with the SPECIAL sequence [5,6]. This new sequence, called MEGA-SPECIAL, enables the use of much longer editing pulses than MEGA-PRESS, thus improving their selectivity and enabling the use of the Henry method to remove MM contamination. Initial results indicate that the MEGA-SPECIAL sequence also yields improved editing efficiency compared to MEGA-PRESS.

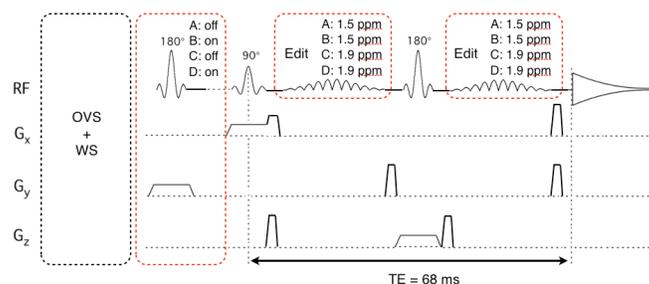


Figure 1. The MEGA-SPECIAL sequence. Dotted red lines indicate sequence elements that change in alternating acquisitions.

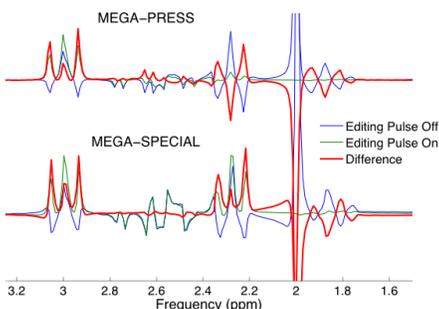


Figure 2. MEGA-PRESS (above) and MEGA-SPECIAL (below) spectra acquired in a NAA+GABA phantom.

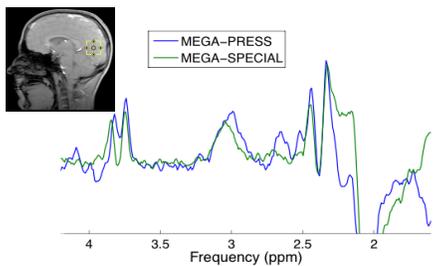


Figure 3. MEGA-PRESS (blue) and MEGA-SPECIAL (green) data acquired in visual cortex of a normal subject.

Methods. All experiments were performed on a 3T Siemens TIM Trio scanner with a body coil transmitter and a 12-channel receive array. **Sequence Design.** The MEGA-SPECIAL sequence was implemented as shown in Figure 1. Because SPECIAL contains only one refocusing pulse during the echo-time (TE), the editing pulse could be lengthened considerably, yielding a 27 ms dual-banded Gaussian pulse with a water suppression band at 4.7 ppm and a GABA editing band at either 1.9 ppm (editing on) or 1.5 ppm (editing off). One full cycle of MEGA-SPECIAL consisted of four acquisitions: A) Inversion off; editing off. B) Inversion on; editing off. C) Inversion off; editing on. D) Inversion on; editing on. The final localized, GABA-edited spectrum S was then obtained from combining the 4 cycles as follows: $S = C - D - (A - B)$. The MEGA-SPECIAL sequence was preceded by outer volume suppression interleaved with VAPOR water suppression [7]. For comparison, the MEGA-PRESS sequence was implemented as described in [1], with editing achieved using a 14 ms, dual-banded Gaussian pulse. **Experiment.** GABA edited spectra were acquired in a phantom containing 100mM GABA and 100 mM NAA using both the MEGA-PRESS and MEGA-SPECIAL sequences (TR/TE = 2000/68 ms, 128 averages, voxel = 30x30x30 mm³). *In-vivo* data were also acquired in the visual cortex of a healthy volunteer using both sequences (TR/TE=2000/68ms, 256 averages, voxel = 30x30x30 mm³). GABA peak intensities were measured in both *in-vivo* and *in-vitro* data using the AMARES software [8].

Results and Discussion. **Results.** Phantom measurements (Figure 2) clearly demonstrate that MEGA-SPECIAL provides improved (36%) GABA edited signal at 3 ppm. Figure 3 shows *in-vivo* edited spectra in the visual cortex of a healthy volunteer using both pulse sequences. The GABA edited signal at 3 ppm is approximately 9% smaller using MEGA-SPECIAL, supporting the hypothesis that unwanted MM signal has been suppressed. **Discussion.** The limiting factor for using the Henry method for GABA editing with MEGA-PRESS at 3T is that when the editing pulse is centred at 1.5 ppm, the tail of the inversion band extends well beyond 1.9ppm, causing unwanted editing in odd scans and resulting in significantly reduced editing efficiency. MEGA-SPECIAL enables an increase in the duration of the editing pulse to 27 ms, thus greatly improving its selectivity so that the GABA multiplet at 1.9 ppm is unaffected when the editing pulse is centred at 1.5 ppm.

Phantom experiments indicate an increase in editing efficiency of approximately 36%. This improvement is likely due to the fact that MEGA-SPECIAL only contains one refocusing pulse during the echo time, thus reducing chemical shift effects. Despite the improved editing efficiency of MEGA-SPECIAL, a reduction in the edited GABA signal was observed *in-vivo* due to successful rejection of MM signals which are present in MEGA-PRESS. Assuming perfect MM suppression in MEGA-SPECIAL, then the edited GABA signal in MEGA-PRESS contained approximately 33% contribution from MM. **Conclusion.** A new pulse sequence has been demonstrated for spectral editing of GABA at 3 Tesla. This new sequence yields an improvement in editing efficiency of approximately 36% compared to MEGA-PRESS, while removing unwanted signal contributions from MM.

References. [1] Mescher M et al. NMR Biomed (1998);11. [2] Rothman DL et al. Proc Natl Acad Sci USA (1993);90. [3] Henry P-G et al. Magn Reson Med (2001);45. [4] Terpstra M et al. Magn Reson Med (2002);47. [5] Mlynarik V et al. Magn Reson Med (2006);56. [6] Mekle R et al. Magn Reson Med (2009);61. [7] Tkac I et al. Magn Reson Med (1999);41. [8] Vanhamme L et al. NMR Biomed (2001);14.