MEGA-edited detection of metabolites with coupled spin-systems: Simulations at high field strengths

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Introduction: At 3T, MEGA editing[1] has proved to be a robust and relatively sensitive strategy for the detection of coupled metabolites whose signals are obscured in conventional, unedited spectrum. An additional strength of the method is its ability to differentiate between pairs of related metabolites[2]. The development of MRS methods at higher field strengths is motivated by anticipated improvements in sensitivity and spectral resolution (Fig 1), and additionally by improved selectivity of editing pulses[3]. However, the relationship between field strength and editing efficiency is complex, and requires numerical simulation in order to be fully evaluated.

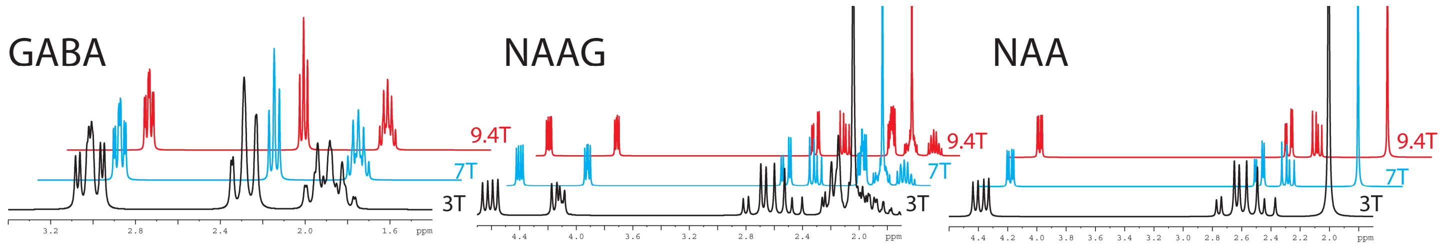

Figure 1. Conventional (TE=0 ms) simulated spectra for GABA, NAAG and NAA at 3, 7 and 9.4T.

Methods: MEGA-PRESS spectra of GABA, NAAG, and NAA spin systems (as described by Govindaraju et al.[4]) were simulated at 3T, 7T and 9.4T, using NMRSIM (Bruker Biospin, Ettlingen). Echo times of 140 ms (NAA and NAAG) and 68 ms (GABA) were chosen initially to reflect common practice at 3T. In order to isolate intrinsic editing sensitivity changes as a result of coupling at different fields, changes in equilibrium polarity, detection sensitivity and transverse relaxation are ignored. The data were processed with exponential filtering, leading to line broadening of 3 Hz, 7 Hz and 9.4 Hz (changing linearly with field in line with experimental experience).

Results and Discussion: Focusing on the principle edited peak of interest, it can be seen that there is significant variation in multiplet form and editing efficiency as field strength increases. The pseudo-doublet acquired for GABA becomes more intense at higher field due to increased overlap. The results for NAAG and NAA is more complex, as the chemical shift difference between the aspartate CH_2 protons becomes more apparent (*cf* Fig. 1).

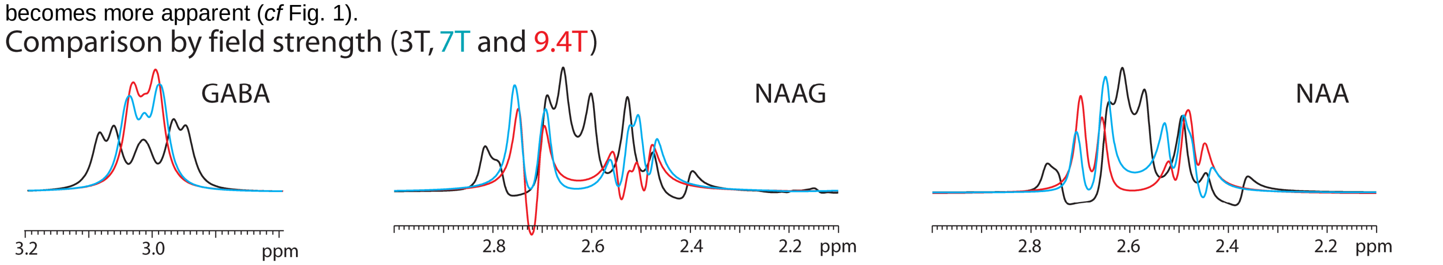

Figure 2. Edited MEGA-PRESS spectra for GABA, NAAG and NAA at 3, 7 and 9.4T.

To investigate this effect more fully, a more extensive series of echo times (80, 100 … 180 ms) were simulated for NAAG and NAA at each field strength (Figure 3). Spectra and integral plots below reveal a number of noteworthy effects. NAAG editing at TE=140ms suffers significantly at higher field strengths (Figure 2 above), but editing at 120 ms is more robust. Significant *negative* edited signal can be achieved at TE=80ms, which may be advantageous at high field when T2 relaxation is more rapid and sufficiently selective pulses can fit into a shorter experiment. Significant *negative* edited signal is also acquired at long echo times, which would accommodate significantly more selective editing pulses addressing a limitation at 3T.

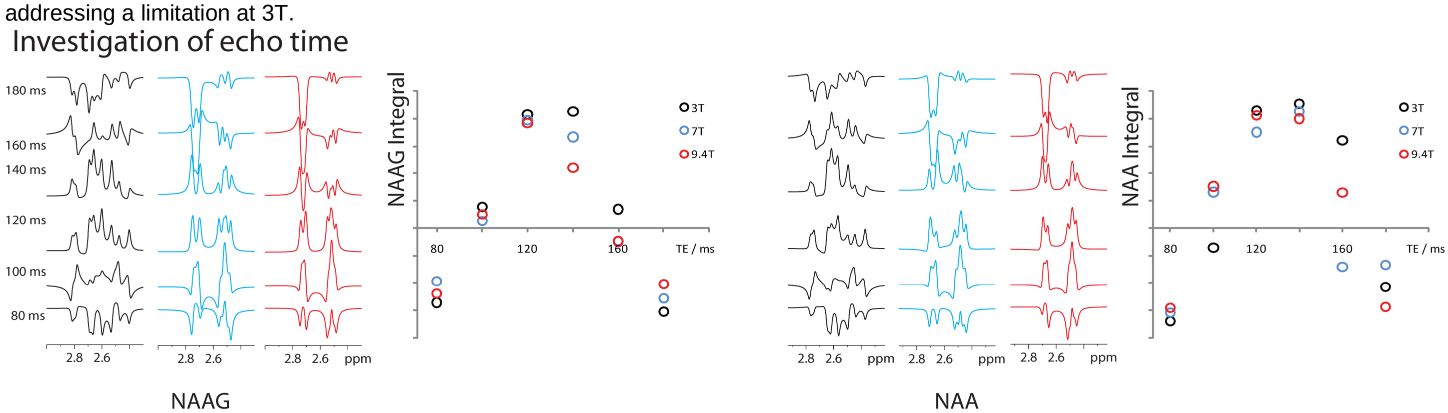

Figure 3. Edited MEGA-PRESS spectra for NAAG and NAA at 3, 7 and 9.4T for echo times varying from 80-180 ms.

Conclusion: Spin-system simulations are pivotal is predicting variations in editing efficiency at different field strengths and selecting optimum echo-time; GABA-editing appears to be favorable at fields higher than 3T, however increased multiplet dispersion may be a problem for NAA and NAAG.

References: 1. Mescher et al. NMR in Biomed 11 (1998), 266. 2. Edden et al. Magn Reson Med 57 (2007), 977. 3. Terpstra et al. Magn Reson Med 47 (2002) 1009 4. Govindaraju et al. NMR Biomed 13 (2000) 129. Supported in part by P41RR15241 and RCUK.