GABA editing at 3T and 7T compared

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Introduction: GABA is the primary inhibitory neurotransmitter of the brain. Due to its low concentration, obtaining sufficient SNR during acquisition is mandatory to ensure reliable GABA measurements. Although scanning at ultra-high field strength (e.g. 7T) increases SNR (compared to 3T) and allows for more selective editing pulses, it also leads to an increase in chemical shift dispersion artifacts and hence problems which signal localization. Moreover, B_1 field amplitudes are limited and B_0 field distortions are increased. Several studies have shown improvements in both SNR and line width between 3T and 7T for short echo time sequences [1]. However, T2 values of most metabolites are reduced at higher field. Therefore, is not obvious if longer echo time sequences, such as the GABA editing sequences, will benefit from scanning at ultra-high field strength as well.

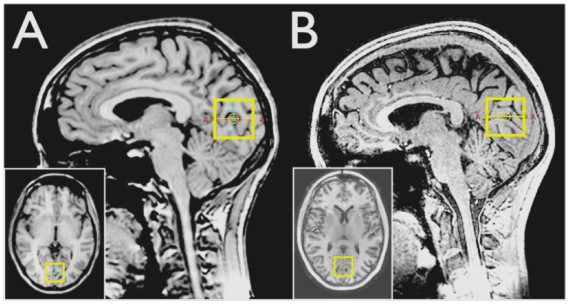

Figure 1. planning of the MRS voxel (3x3x3 cm) in the occipital lobe at 3T (a) and 7T (b) for GABA editing.

Methods: To compare GABA measurements, we scanned 5 healthy volunteers twice (1x 3T and 1x 7T) after written informed consent was obtained. Two implementations of a standard editing sequence for GABA detection with macromolecule suppression were used. On 3T (Philips, Best, The Netherlands), data was acquired using PRESS localization (TE = 80ms, TR =2s, 14ms Gaussian editing pulses [2]) icw a 8-channel phased array receive head coil. At 7T (Philips, Cleveland, US) sLASER localization (TE=64, TR=5, 8ms dual band editing pulse [3]) was used to counter the increased chemical shift dispersion in combination with a dual-transmit volume head coil to realize the required B_1 values in the voxel. A 32-channel receive array was used for signal reception. Second order localized shimming was performed in all experiments. A water reference was acquired for optimal receiver coil addition. In both acquisitions the voxel ($3x3x3cm^3$) was placed in the parietal/occipital lobe (Fig. 1). Both the 3T and 7T scan were performed in 10 min. GABA and creatine intensities were estimated from a Gaussian fit to the data after field strength dependent apodization [1]. SNR was defined as the peak height divided by the standard deviation of the noise in the spectral domain.

Results: The average SNR over the five volunteers for GABA was 12.6 at 3T, 25.7 at 7T. SNR of creatine was 594 at 3T, 855 at 7T. High reproducibility at 3T, and an even better reproducibility at 7T can been seen from the overlay of the spectra in figure 2.

Discussion: Although MRS acquisitions at 7T can suffer from inhomogeneous B_1 and B_0 fields and increased chemical shift dispersions artifacts, with the high bandwidth pulses of an sLASER sequence these technical challenges can be countered. Already from the limited number of people scanned here we can see a good reproducibility from the overlay of the spectra (fig2). Even with the lower number of averages at 7T (due to higher RF power deposition at 7T), reproducibility seems to be slightly increased with as compared to 3T. The SNR of creatine increased by 40%. For GABA an SNR increase of ~100% was observed, possibly due to smaller difference in T2 values, and in the intrinsic multiplet decoupling due to the larger chemical shift dispersion.
We conclude that GABA acquisitions at 7T provide higher SNR, and can therefore be performed in shorter scan times or with smaller voxels as compared to an acquisition at 3T.

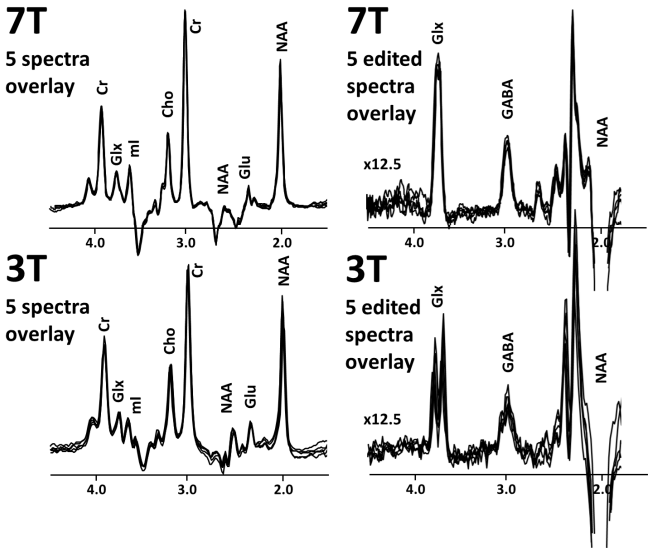

Figure 2. Overlay of the spectra of five volunteers, all scaled to creatine, scanned at both 3T and 7T. Summed spectra (left) show good repeatability of the measurement at 3T, and excellent repeatability at 7T. Edited spectra (right, 12.5x increased scaling) clearly shows the GABA resonance at 3.0 ppm in all volunteers with a strong overlap between the volunteers.

Acknowledgement: We greatly appreciate the help of dr .Edden, making the 3T GABA editing sequence available.
References: 1. Otazo MRM 2006; 2. Edden MRM 2012 3. Andreychenko MRM 2012