High resolution MR Spectroscopic imaging of the visual cortex at 9.4T with minimal chemical shift displacement artefact

Desmond H.Y. Tse[1], Vincent O. Boer[2], Valentin G. Kemper[3], Dennis W.J. Klomp[2], and Jacobus F.A. Jansen[1]
[1]*Radiology, Maastricht UMC, Maastricht, Netherlands,* [2]*Radiology, UMC Utrecht, Utrecht, Netherlands,* [3]*Cognitive Neuroscience FPN, Maastricht University, Maastricht, Netherlands*

Target audience
MR physicist and neuroscientists

Purpose
^{1}H-MR Spectroscopy (^{1}H-MRS) enables the non-invasive quantification of in vivo metabolite concentrations in the brain, thus offering a window on cell metabolism. With ^{1}H-MRS imaging (MRSI), multiple spectra can be obtained simultaneously from multiple adjoining spatial regions. An ultrahigh field (UHF) strength of 9.4T is beneficial, as it offers intrinsic advantages of increased signal to noise ratio and increased spectral resolution [1,2]. However, due to limitations in B1 performances, so far, only STEAM MRSI localizations have been obtained at 9.4T, thereby not using the SNR advantage of UHF [2]. In this work we demonstrate that by combining an 8 channel half volume coil for relatively high B1 combined with high bandwidth GOIA (gradient offset independent adiabatic) pulses [3], we can obtain the full potential of quantified MRSI at 9.4T in the visual cortex.

Methods Data was acquired on a healthy subject using a 9.4T human MR scanner (Magnetom 9.4T, Siemens Medical Solutions, Erlangen, Germany) in combination with a half volume RF coil (24 channel receive, 8 channel transmit; Life Services, Minneapolis, MN, USA). A static B1+ phase shim set (no amplitude modulation) which was optimized for efficiency in early visual areas (not subject-specific) was applied for all measurements. Anatomical images were acquired using a 1mm^3 isotropic MPRAGE sequence, DREAM was used for volumetric B1+ mapping (Fig. 1) [5], B0 maps were acquired for shimming using 3D double-echo GRE (TE1 1ms, TE2 3.21ms, TR 30ms, FA 8^o, 3 mm isotropic voxel size) (Fig. 1), and MRSI was acquired in the occipital cortex (Fig. 2) using a 2D semi-LASER [5] with adiabatic GOIA pulses [3] (FOV 104x104mm, matrix 16x16, VOI 60x60mm, slice thickness 13mm, excitation acquisition bandwidth 3700 Hz, 2048 spectral points, TR 5 s, TE 38 ms, voxel size 6.5x6.5x13mm, VAPOR water-suppression, 4 averages with elliptical sampling, measurement time 23:50 min, pulse timings 5.05, 13.65, 21.45, and 31.85 ms, GOIA: B1max 16 uT, duration 6.7 ms, bandwidth 16800 Hz). MRSI spectra were analyzed using LCModel (Version 6.3-1B) (fig 3) [6]. The metabolite basis set (sLASER, TE 38 ms, 9.4 T) was simulated using VeSPA [7] and a macromolecule spectrum was acquired separately.

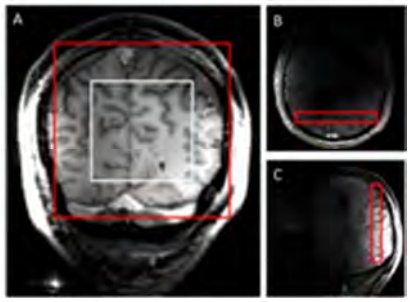

Fig. 2 A) Coronal, B) Axial, and C) Sagittal MPRAGE with MRSI FOV in red and VOI in white.

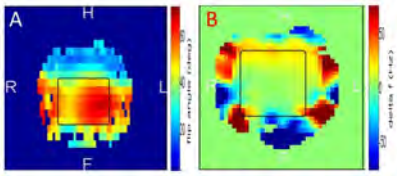

Fig. 1 Coronal A) B1+ and B) B0 maps with MRSI slice indicated in black.

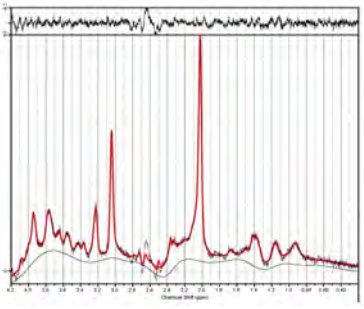

Fig. 3 Example of LCModel fit.

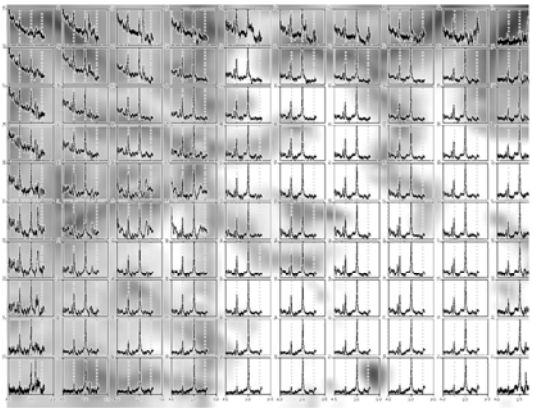

Fig. 4 Grid with individual spectra in white VOI.

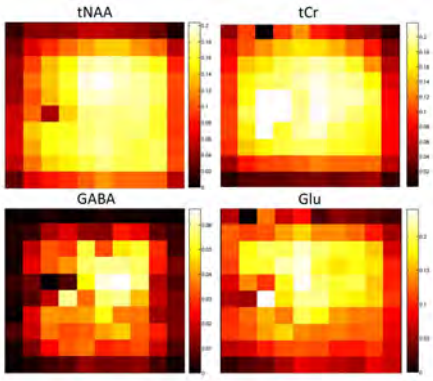

Fig. 5 Metabolic maps (in a.u.) within white VOI with original acquisition resolution.

Results & Discussion
Within the VOI, spectra with high spectral resolution (0.03 ppm NAA) and SNR (range 20-33) and no lipid contamination were obtained facilitating good fits, also for heavily overlapping metabolites, including glutamate and GABA (Fig. 3,4). Due to the application of GOIA pulses, chemical shift displacement artefact (CSDA) was minimal, however, the 90 degree excitation pulse (left-right) still shows a CSDA of ~2 voxels (NAA versus Ins). Interestingly, neurotransmitters GABA and glutamate show similar spatial distributions (Fig. 5).

Conclusion
For the first time, quantified spectra with high spatial and spectral resolution of the human visual cortex are obtained at 9.4T with maximum SNR and minimal CSDA.

References
[1] Deelchand et al. JMR 2010, [2] Chadzynski et al. MAGMA 2014, [3] Tannus and Garwoord, NMR Biomed 1997, [4] Nehrke K, et al. MRM 2012, [5] Scheenen et al. MAGMA 2008, [6] Provencher, MRM 1993, [7] Soher et al. ISMRM 2011.