Multi-center Reproducibility of Short Echo Time Single Voxel ^{1}H MRS of the Human Brain at 7T with Adiabatic Slice-Selective Refocusing Pulses

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Purpose: The higher sensitivity and increased spectral resolution at ultra-high magnetic field strengths enables a higher accuracy in the detection and quantification of neurochemical profiles obtained from the human brain using ^{1}H MRS. However, spatial selective excitation and refocusing remains challenging due to the relatively low available B_1-amplitudes. The solution to these challenges is found in the semi-LASER sequence [1], which uses adiabatic and therefore high bandwidth refocusing pulses while TE remains relatively short with small chemical shift displacement errors. The sLASER technique is proven robust and reproducible in MRSI at 3T [2], and showed promising results at 7T [3]. The aim of this study is to test the robustness and reproducibility of sLASER at 7T by means of an inter- and intra-subject, -institution and -vendor comparison.

Methods: Seven volunteers were scanned twice each at four different 7T whole body MR systems located at Center for Magnetic Resonance Research (CMRR, University of Minnesota, Minneapolis, USA) equipped with Siemens console, Erwin L. Hahn institute (ELH, Siemens Magnetom 7T, Erlangen), University Medical Center Utrecht (UMCU, Philips Achieva 7T) and Leiden University Medical Center (LUMC, Philips Achieva 7T). At CMRR a home-built 16-channel transceive array-coil [4] was used in combination with local B_1-shimming [5], as described before [6]. At the other institutes the 32-channel receive array head-coil by Nova Medical was used, where 2-channel B_1-shimming was applied at both Philips systems. From each volunteer single voxel spectra (TR/TE=8000/30ms, NEX=64) from the posterior cingulate cortex (20x20x20mm^3) and from the left side of the corona radiata (18x18x18mm^3) were obtained using a modified semi-LASER sequence [3,7]. Subsequently, additional water files were obtained for Eddy Current Correction and for optimized signal combination. Spectra were analyzed with LCModel [8], using a simulated basis set including an experimentally acquired macromolecular baseline (TR/TE/TI=2000/24/685ms). Voxels were carefully and manually repositioned at the location of interest for all scans of the same volunteer.

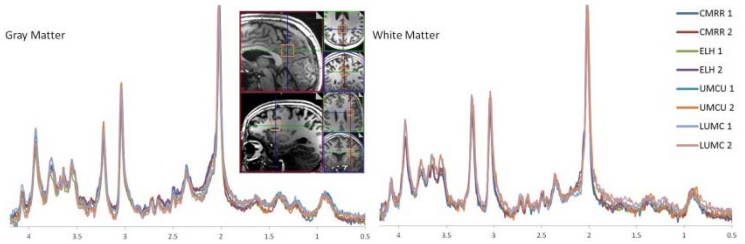

Figure 1) Reproducibility of spectral quality within- and between sites. Spectra (normalized to NAA) of a single subject obtained at four different 7Tesla systems are shown. The image inset depicts the position of the gray matter voxel, the color legend indicates the different sites at which the spectrum was acquired.

Results and discussion: In figure 1 all spectra obtained from a single volunteer are displayed. Note that each spectrum has high quality and almost complete overlap exists between scans and re-scans at all four institutes in both gray and white matter. Using the macromolecular baseline determined from one site (CMRR), variations in quantification results per subject are small, as shown in figure 2. Only for Gln, a vendor specific difference is observed between the quantified results that extends beyond the variations per subject. As the gradient system differs between these sites, a measured basis set per vendor may improve quantification results even further. High accuracy in repeatability was obtained (Fig 3) with standard errors substantially smaller than observed between subjects, indicating that MRS at 7T enables observation of small physiologic differences in metabolite levels between subjects.

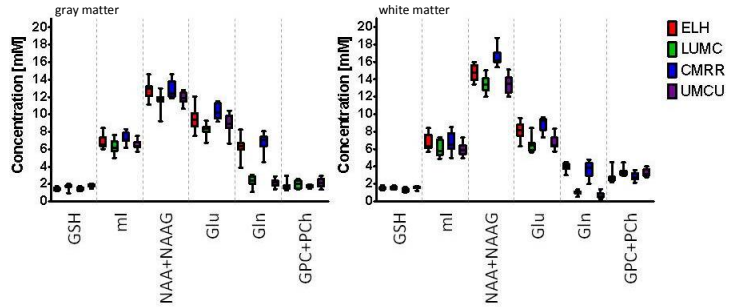

Figure 2) Box and whisker plot of LCModel quantification results for a few metabolites per institution (Red - ELH, Green - LUMC, Blue - CMRR, Purple - UMCU, show from left to right for each metabolite). The presented metabolites had a CRLB < 5, except for GSH (CRLB < 15) and Gln (CRLB < 25), and were normalized to total Creatine (Cre+PCr) at a concentration of 8mM. The between-site reproducibility for most metabolites is very good, an exception can be seen for Gln. Abbreviations: Glycerophosphocholine (GPC) and phosphocholine (PCh), glutamate (Glu) and glutamine (Gln), N-acetylaspartate(glutamate) (NAA(G)), glutathione (GSH) and myo-inositol (mI).

Conclusion: Accurate and high quality single voxel proton spectra could be acquired from seven volunteers at four different institutes with MRI systems from two different vendors, with high within- and between-institution and vendor reproducibility. Despite the fact that a different coil setup was used at one of the institutes, and that voxels were manually repositioned at the location of interest, the sLASER technique at 7T is a very robust method that is well suited for multi-site, multi-vendor studies of neurochemical profiles of the human brain.

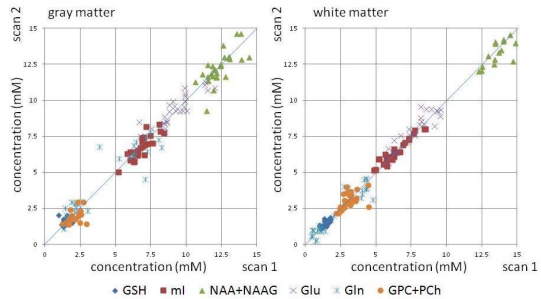

Figure 3) Within subject comparison of a few selected metabolites (see figure 2). The close proximity of these metabolites to the identity line reveals high within institution reproducibility.

References: [1] Scheenen *et al.*, MRM 59:1-6 (2008) [2] Wijnen *et al.*, MRM 31:61-70 (2010) [3] Boer *et al.*, NMR Biomed 24, 9:1038-1046 (2011) [4] Adriany *et al.*, MRM 59:590–597 (2008) [5] Metzger *et al.*, MRM 59:396-409 (2008) [6] Emir *et al.*, NMR Biomed 25:152-160 (2012) [7] Öz & Tkáč, MRM 65:901–910 (2011) [8] Provencher, MRM 30:672-679 (1993).

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