Reproducibility of Anterior Cingulate ^{1}H MRS Data at 7T

S. Andrea Wijtenburg[1], Laura M. Rowland[1], Elena A. Spieker[1], Richard A. E. Edden[2,3], and Peter B. Barker[2,3]

[1]Maryland Psychiatric Research Center, Department of Psychiatry, University of Maryland School of Medicine, Baltimore, MD, United States, [2]Russell H. Morgan Department of Radiology and Radiological Science, Johns Hopkins School of Medicine, Baltimore, MD, United States, [3]F.M. Kirby Research Center for Functional Brain Imaging, Kennedy Krieger Institute, Baltimore, MD, United States

Introduction: High field human MR systems such as 7T and 9.4T (1,2) are becoming quite widely available in academic medical centers. For studies of the brain using proton MR spectroscopy, they offer the advantages of increased frequency separation and SNR (3) compared to lower field strengths. However, there are also technical challenges associated with high field strengths, such as increased susceptibility effects, inhomogeneous transmit (B_1) fields, and increased chemical shift dispersion (CSD). Therefore, it is important to establish reproducibility of 7T MRS in normal subjects before undertaking studies in neurological or psychiatric diseases. To our knowledge, reproducibility studies of 7T spectroscopic data have yet to be reported. In this study, 7T spectroscopic data were acquired from healthy volunteers on two separate visits about one week apart, in order to determine the reproducibility of short TE STEAM localization of the anterior cingulate cortex (ACC). The ACC was chosen since this is believed to be a key region of involvement in psychiatric diseases such as schizophrenia.

Methods: Using a 7T Philips Achieva scanner with a 32-channel head coil (Nova Medical), spectroscopic data were acquired from the ACC (Figure 1) in four healthy subjects (2 male/2 female, mean age: 24.1 ± 2.3) each scanned twice (average duration between scans: 8 ± 2 days). STEAM spectroscopic parameters were: TR/TM/TE = 3000/25/14-ms, NEX=32, scan time 1 min 36 sec, 2048 complex points, 3-kHz spectral bandwidth, VOI~27-cm^3. Prior to acquisition, localized power optimization and projection-based high order shimming were performed. In addition, a water reference was acquired for phase and eddy current correction, and quantification. Basis set spectra were generated in GAVA (4) and used for spectroscopic quantification in LCModel (5). All metabolite concentrations were reported in institutional units, and only metabolites with CRLBs < 20% were used in reproducibility calculations. Mean coefficient of variation (CV) and % difference in concentrations were calculated.

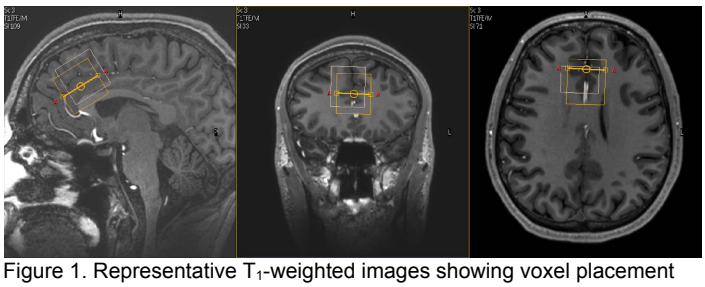

Figure 1. Representative T_1-weighted images showing voxel placement along the midline of the anterior cingulate.

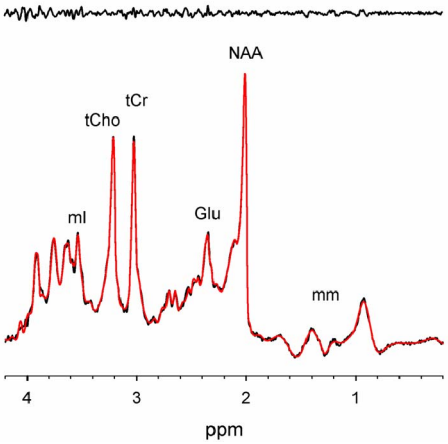

Figure 2. Representative 14-ms TE spectrum (-) from the anterior cingulate cortex with the LCModel fit (-) and residue (shown above, -) shows excellent fits.

Results and Discussion: Figure 2 shows a representative spectrum from the ACC. CRLBs for all metabolites reported in Table 1 were less than 11%, and all mean CV values were less than 15%. As expected, NAA, tCr, mI, Glu, mI+Gly, and tNAA had mean absolute differences between visits of 10% or less. tCho, one of the dominant peaks in the spectrum, did not have the superior reproducibility of NAA and tCr at 16.7%. These values may be affected by the overlapping resonances of PE and Tau included in our basis set. While PE was consistently identified, Tau fits were good in some cases (CRLB <20%) and poor in others (CRLB > 20%), which may have negatively influenced the tCho fits. Absolute differences for GABA and NAAG were surprisingly good at 8.7% and 14.3%. The excellent reproducibility of GABA and NAAG suggest that complex spectral editing techniques may not be necessary at higher field strengths where the increased frequency separation allows for reliable measurements of these metabolites. The mean absolute differences for these metabolites may perhaps be further improved by selection of a smaller voxel size, leading to a more homogeneous sample, and increased scan times. However, these data provide proof that excellent reproducibility can be achieved using a 7T STEAM localization sequence *in vivo*.

Table 1. Metabolite concentrations from the ACC with CRLB ≤ 20%

Metabolites	Mean Conc. (IU)	Mean CV (%)	Mean Abs Diff (%)
NAA	12.71 (V1) 13.18 (V2)	4.2	6.3
tCho	2.41 (V1) 2.46 (V2)	10.8	16.7
tCr	9.22 (V1) 8.75 (V2)	4.2	5.8
mI	6.72 (V1) 6.96 (V2)	6.9	10.0
Glu	16.09 (V1) 15.09 (V2)	4.6	6.2
Gln	3.79 (V1) 3.11 (V2)	14.6	18.4
GABA	3.58 (V1) 3.45 (V2)	6.3	8.7
NAAG	3.35 (V1) 2.93 (V2)	11.2	14.3
tNAA	16.06 (V1) 16.11 (V2)	2.4	3.4
mI+Gly	8.13 (V1) 8.30 (V2)	5.4	7.7

Conc. – Concentration; IU - institutional units; V1 – Visit 1; V2 – Visit 2

References: (1) Tkac I et al. Magn Reson Med 2001. 46:451-6. (2) Deelchand DK et al. J Magn Reson 2010. 206: 74-80. (3) Tkac I et al. Magn Reson Med 2009. 62:868-79 (4) Soher BJ et al. J Magn Reson 2007. 185:291-9. (5) Provencher SW. Magn Reson Med 1993. 30:672-9.