Reproducibility of glutamate measurement in the human brain with 1H-MRS at 7T: evaluation of the sLASER sequence

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Introduction

In vivo ^{1}H-MRS at 7T can be used to accurately determine glutamate (Glu) levels in the human brain, which is important when studying a variety of neurological and neuropsychiatric disorders. Especially at short echo time (TE), the full in-phase glutamate signal can be acquired at high sensitivity. At ultra high field, most studies use the stimulated echo acquisition mode (STEAM) for localization. Recently, a sLASER (semi-localized by adiabatic selective refocusing) sequence has been developed that can be applied at 7T using field focusing at short TE [1] resulting in twice as much signal as can be obtained by using STEAM (fig.1). Purpose of this study was to assess the reliability and reproducibility of the sLASER sequence compared to the STEAM sequence.

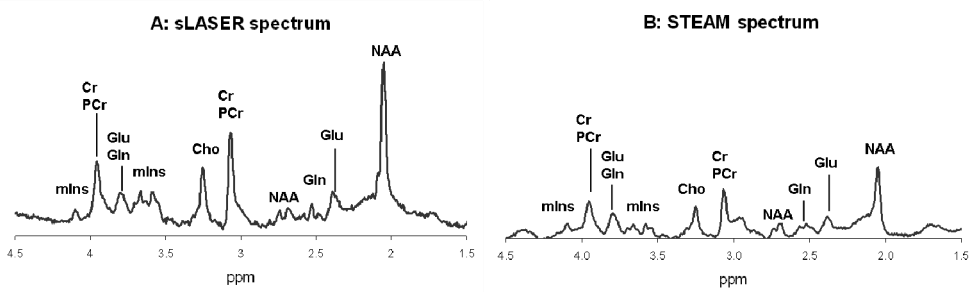

Fig.1: Typical spectra for the sLASER sequence (A) and STEAM sequence (B).

Materials/Methods

Participants: Eight healthy subjects (21-29 yr, mean ± SD=23.9 ± 2.4 yr, 3 males, 5 females) were scanned twice, with two weeks between the measurements.

MR acquisition: ^{1}H-MRS experiments were performed with two short TE sequences (STEAM: TE=7.8ms, 128 averages, TR=2s; sLASER: TE=28ms, 16 averages, TR=5s) on a 7T whole body MR scanner. A birdcage transmit head coil was used and driven in dual transmit, in combination with a 16-channel receive coil (both Nova Medical, Inc., Burlington, MA, USA). The voxels of interest (VOI) were located in the left frontal and parietal/occipital lobe (fig.2). Non water suppressed spectra were obtained in order to calculate absolute concentrations of metabolites.

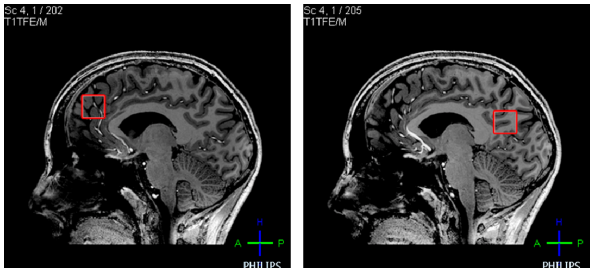

Fig.2: Frontal (left) and occipital (right) VOIs (size 2x2x2 cm).

Spectral fitting and quantification: Spectral fitting was performed with LCModel based software implemented in Matlab [2], which uses a priori knowledge of the spectral components (Glu, Gln, GSH, mIns, NAA, Cho, Cr, PE and measured MM-baseline) to fit metabolite resonances [3]. To correct for the contribution of gray matter, white matter and cerebrospinal fluid in each VOI, segmentation was performed using the SPM8 software package.

Statistics: To assess the reproducibility of Glu measurements, a test-retest reliability test was performed (SPSS 15.0, Chicago) for each sequence and VOI, by calculating the intraclass correlation coefficient (ICC) using a two-way random model ANOVA.

Results

The sLASER sequence has significant ICC's for glutamate concentration in both the frontal and occipital VOI (fig.3A&C). In fact, the accuracy and reproducibility with the sLASER at 7T was sufficient to detect physiological differences between the subjects. The STEAM sequence on the other hand did not show any significant correlations (fig.3B&D) probably due to its lower localization accuracy and/or B_1 sensitivity.

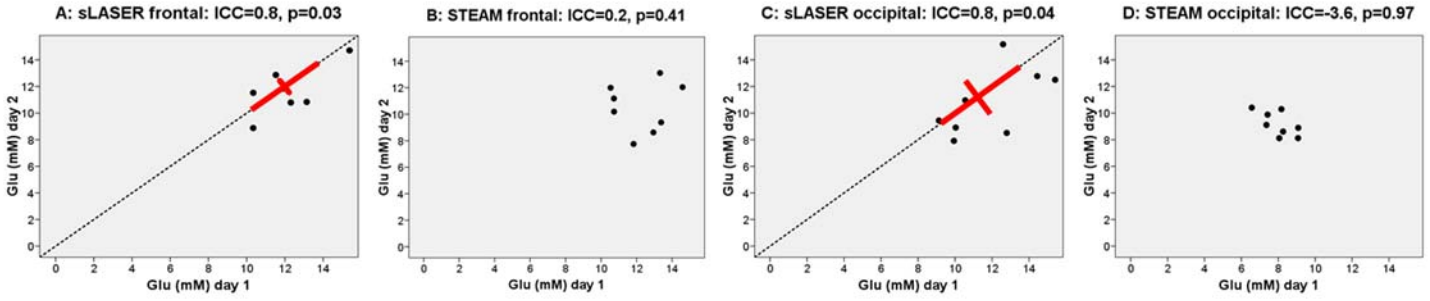

Fig.3: Correlation between Glu concentrations (mM) at the first measurement (x-axis) and second measurement (y-axis). A: Glu measured with sLASER in the frontal lobe; B: Glu measured with STEAM in the frontal lobe; C: Glu measured with sLASER in the occipital lobe; D: Glu measured with STEAM in the occipital lobe.

Conclusion

We conclude that sLASER ^{1}H-MRS at 7T is a reliable method to obtain reproducible measures of Glu levels in the human brain at higher accuracy than physiological variability, even between age matched subjects.

References

1. Boer et al., 2010, NMR Biomed; 2. De Graaf, 1999; Govindaraju et al., 2000, NMR Biomed