Resolution Enhancement of Brain Glutamate at PRESS {TE1, TE2} = {35, 75} ms at 3T

C. Choi[1], N. J. Coupland[2], P. Seres[3], C. Zhao[1], S. Kalra[4], and P. G. Tibbo[2]

[1]Advanced Imaging Research Center, University of Texas Southwestern Medical Center, Dallas, Texas, United States, [2]Psychiatry, University of Alberta, Edmonton, Alberta, Canada, [3]Biomedical Engineering, University of Alberta, Edmonton, Alberta, Canada, [4]Medicine, University of Alberta, Edmonton, Alberta, Canada

INTRODUCTION

Despite its relatively high brain concentration, the precision of glutamate (Glu) measurement by short-TE conventional ^{1}H-MRS is limited at clinically accessible magnetic fields by the overlapping multiplets of glutamine (Gln), N-acetylaspartate (NAA) aspartate moiety, glutathione (GSH) Glu moiety, and by macromolecule (MM) signals. An alternative long-TE approach can be employed, with the advantages that TE optimization can suppress the scalar-coupled resonances of the neighboring interferences, reduce the MM baseline, and yet preserve sufficient signal to noise ratio for measurement of the Glu multiplet within a clinically acceptable time frame. A recent paper indicated that PRESS (point-resolved spectroscopy) provides enhanced resolution of Glu at TE = 80 ms [1], followed by several clinical studies [2]. The complex behavior of the signals from strongly-coupled resonances requires rigorous investigation of the signal dependence on the sequence parameters. Here, we present a preliminary result of optimization of the PRESS echo times TE_1 and TE_2 for further enhanced resolution of Glu in brain in vivo.

METHODS

Density-matrix simulation was employed to search for optimal subecho times TE_1 and TE_2 of a single-voxel localized PRESS sequence, incorporating slice-selective RF pulses and gradients. The sequence consisted of a 90° RF pulse (9 lobes; 3.0 ms; BW = 3.8 kHz) and two 180° RF pulses (9 lobes; 7.6 ms; BW = 1.0 kHz). The effects of T_1 and T_2 relaxation were not included in the simulation. The published chemical shift and coupling constants [3] were used. The density-matrix simulation was programmed with Matlab (The MathWorks, Inc.).

In vivo validation of the echo time optimized PRESS was performed for two brain regions (gray-matter rich medial parietal and white-matter rich left frontal; voxel size 30×30×30 mm^3) of a healthy volunteer. Experiments were carried out at 3.0 T in an 80-cm bore magnet, interfaced to a SMIS console. A 28-cm diameter quadrature birdcage coil was used for RF transmission and reception.

RESULTS AND DISCUSSION

Fig. 1 illustrates the pattern of the echo time dependence of PRESS spectra of Glu, Gln, NAA and GSH, for concentration ratio of 9:2:9:1. Since the resonances are strongly coupled, the signals degrade drastically with echo time, exhibiting substantial antiphase component in the signals at TE_1 = TE_2 = 30 ms. The Glu signal is maximal at TE_1 = TE_2 = 50 ms among symmetric subecho times. The Glu multiplet becomes greater at an asymmetric subecho time set {TE_1, TE_2} = {35, 75} ms, whilst the signal intensity of Gln, NAA and GSH remains about the same relative to Glu for all echo times illustrated in Fig. 1.

Fig. 2 presents calculated and in-vivo brain PRESS spectra, together with calculated 90°-acquired spectra. A numerical calculation indicates that the amplitudes of the Glu multiplet at {TE_1, TE_2} = {40, 40}, and {35, 75} ms are 37% and 73% with respect to a 90°-acquired multiplet, respectively. Therefore, with similar amplitude of the interference signals, Glu can be measured more reliably at {TE_1, TE_2} = {35, 75} ms, despite the slight signal loss due to the T_2 effect. With a concentration ratio 9:2:9:1:8 between Glu, Gln, NAA, GSH and Cr, the sum of the calculated spectra is in good agreement with in-vivo spectra from the medial parietal and left frontal cortices, for both sets of subecho times. In conclusion, PRESS Glu resolution is substantially enhanced at {TE_1, TE_2} = {35, 75} ms.

REFERENCES

1. Schubert F *et al.* Neuroimage 2004;21:1762-1771.
2. Griffith HR *et al.*, NMR Biomed (2007: DOI:10.1002/nbm.1203).
3. Govindaraju V *et. al.*, NMR Biomed 2000;13:129-153.

This research was supported by Canadian Institutes for Health Research.

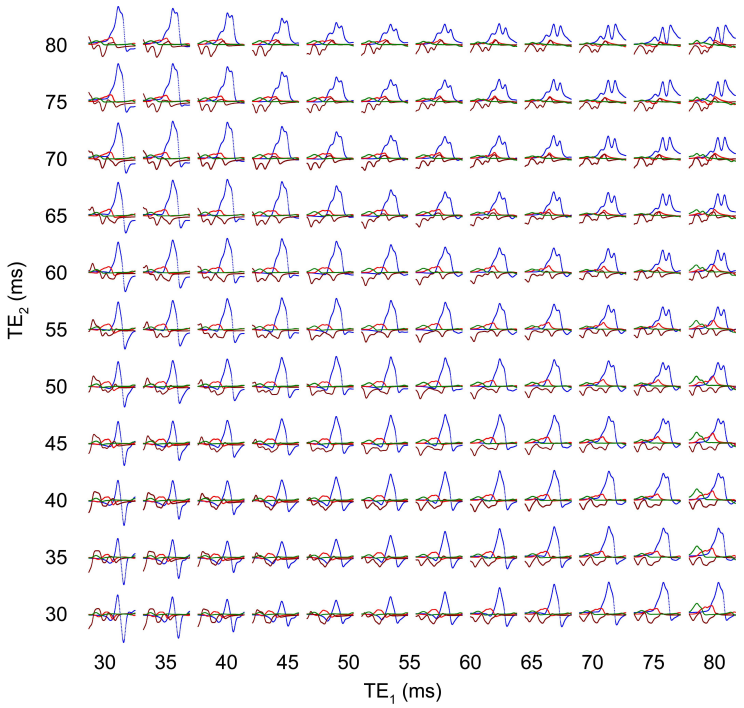

FIG. 1. Numerically-calculated PRESS spectra of Glu (blue), Gln (red), NAA (brown) and GSH (green) for concentration ratio of 9:2:9:1, for the sub echo times TE_1 and TE_2 as indicated. Spectra were broadened with a 5-Hz exponential function.

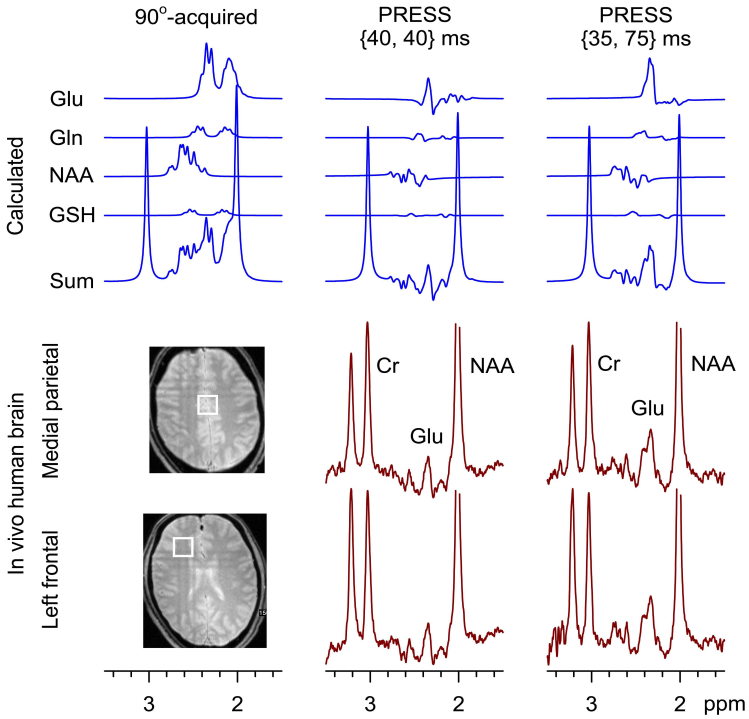

FIG. 2. In-vivo brain spectra (25×25×25 mm^3) from PRESS echo times {TE_1, TE_2} = {40, 40} and {35, 75} ms are plotted together with calculated spectra and their sum for [Glu]/[Gln]/[NAA]/[GSH]/[Cr] = 9:2:9:1:8. Calculated spectra were broadened to match in-vivo linewidth (5 Hz). Spectra are normalized relative to the Cr 3.03-ppm peak amplitude. TR = 2.4 s. NEX = 64.