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Comparison of polarization-enhanced ^{13}C MR spectroscopy with different ^{1}H localization schemes at 7T

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BACKGROUND

Localized ^{13}C MR spectroscopy is a powerful technique to probe key information on metabolites and metabolic rates to study cerebral metabolic pathways[1]. The combination of distortionless enhancement by polarization transfer (DEPT)[3] and proton Image-selected in vivo spectroscopy (ISIS)[4] has been developed and applied to measure the ^{13}C labeled cerebral metabolites, enabling a localized detection of the metabolites and reducing chemical shift displacement errors (CSDEs) relative to direct ^{13}C localization[1,5]. However, ISIS requires eight scans and the resulting spectra suffer from possible motion artifacts. Recently, PRESS-localized DEPT[6,7] has been implemented, providing reliable enhanced and localized ^{13}C metabolite signals. In comparison with PRESS, sSPECIAL[8] and STEAM[9] provide better localization performances with lower CSDEs at 7T, and shorter echo times reducing signal losses due to T_2 relaxation and J-evolution[10]. As sSPECIAL only requires two scans and STEAM is a single-shot technique, they are expected to be less sensitive to motion relative to ISIS-based localization. In this study, we implemented sSPECIAL-DEPT and STEAM-DEPT at 7T and compared their performances with ISIS-DEPT using in vitro experiments.

AIMS

In this study, we aimed to develop a combination of DEPT with sSPECIAL and STEAM localization on proton frequency, which can provide an enhanced ^{13}C signal as well as excellent localization.

RESULTS

- The good localization performances were validated by the absence of lipid residue from the outer-volume peanut oil compartment.
- In comparison to the spectra of ISIS-DEPT, the signal intensity of sSPECIAL-DEPT is 18% lower, which is mainly caused by the ^{1}H T_2 relaxation losses during the TE (12 ms) of sSPECIAL (measured T_2 is 75 ms; T_1 is 550-650 ms).
- The signal intensity of STEAM-DEPT spectra is approximately half of that of sSPECIAL-DEPT due to the 50% signal loss in the STEAM sequence.

METHODS

- **Materials**: 7T human MR scanner (Siemens Medical Solutions, Erlangen, Germany); a dual-tuned ^{1}H-^{13}C RF surface coil[11]; a two-compartment phantom (the outer chamber contains 1200 mL peanut oil and the inner chamber contains 300 mL glutamate with a concentration of 600 mM).
- **MR spectroscopy**: The ISIS-DEPT, sSPECIAL-DEPT, and STEAM-DEPT sequences were implemented. The minimum achievable echo time was 12 ms for sSPECIAL and 4.5 ms for STEAM. The pulses in the DEPT part were all hard pulses and the delay was set to 3.7 ms (corresponding to $1/2J_{CH}$) for the detection of glutamate CH_2 groups. The last ^{1}H DEPT pulse flip angle θ was set to 45° to achieve the maximal CH_2 enhancement. 3D B_0 shimming was performed to improve the field homogeneity on the ^{1}H frequency. The carrier frequency of ^{13}C frequency pulses was set at 31 ppm between Glu-C3 and Glu-C4 resonances. (TR = 4s; 64 averages; bandwidth = 4kHz; voxel size = 2048; VOI size = 25x25x25 mm^3).

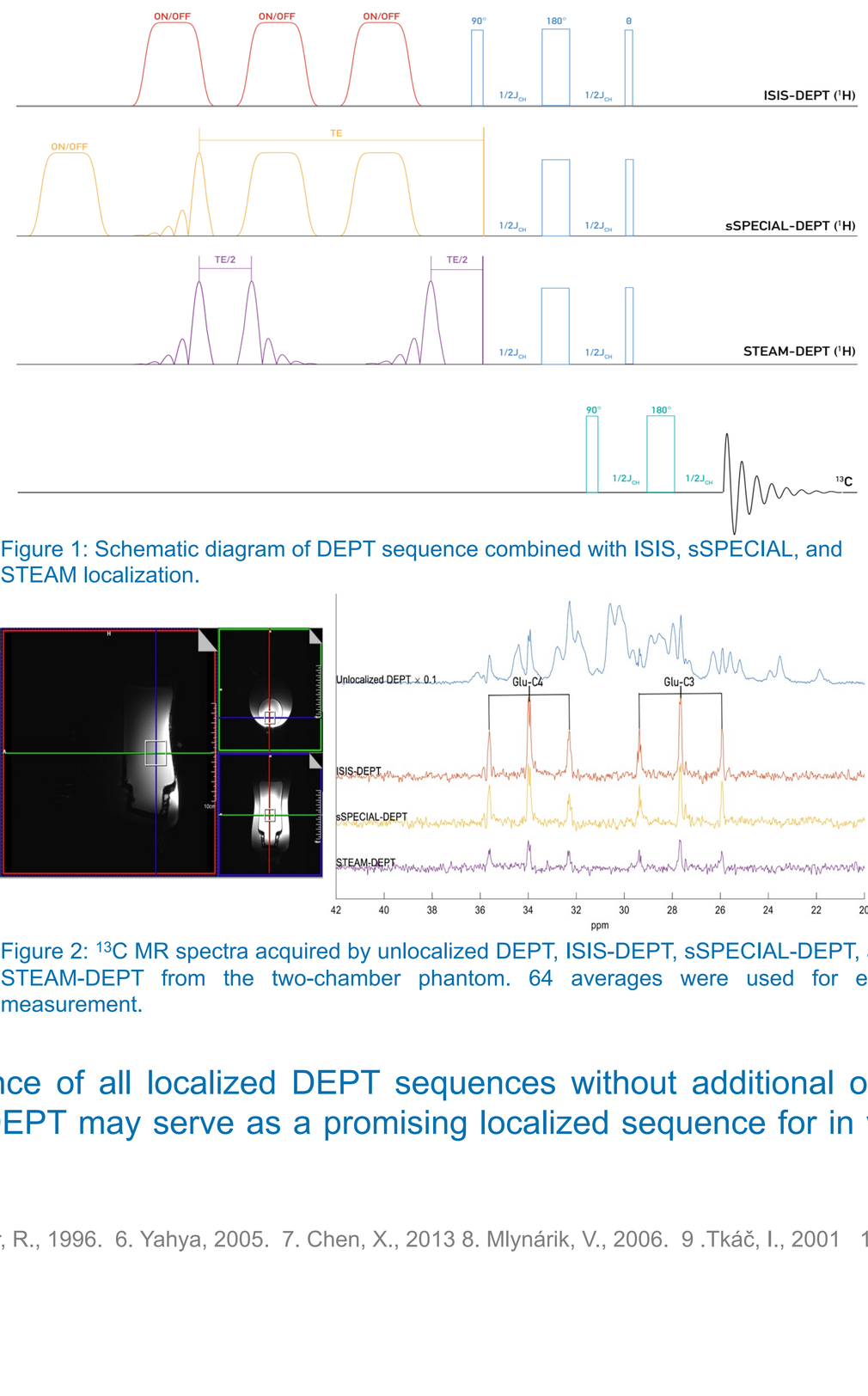

Figure 1: Schematic diagram of DEPT sequence combined with ISIS, sSPECIAL, and STEAM localization.

Figure 2: ^{13}C MR spectra acquired by unlocalized DEPT, ISIS-DEPT, sSPECIAL-DEPT, and STEAM-DEPT from the two-chamber phantom. 64 averages were used for each measurement.

CONCLUSION

The phantom experiments demonstrated good localization performance of all localized DEPT sequences without additional outer volume suppression (OVS) modules. sSPECIAL-DEPT and STEAM-DEPT may serve as a promising localized sequence for in vivo ^{13}C MRS studies at 7T depending on the region of investigation.

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