Human Brain Non Echo 3D Hadamard Spectroscopic Imaging

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Introduction: Localization in spectroscopic imaging is commonly achieved using the intersection of 3 orthogonal pulses; either $90°_X$–$180°_Y$–$180°_Z$ spin echo (PRESS) or $90°_X$–$90°_Y$–$90°_Z$ stimulated echo (STEAM). Multivoxel localization can be done using either chemical shift imaging or Hadamard spectroscopic imaging (HSI). Typical echo times for PRESS range from 25ms to 270ms, sustaining T_2 losses of 7-50% for PRESS [1] or an *intrinsic* 50% for STEAM [2]. Here we present and demonstrate a non-echo 3D sequence that overcomes both limitation.

Theory: HSI encodes the spins' phase in a slice at either 0°or 180° corresponding to the +1 or -1s of each row of a Hadamard matrix [3]. The first slice-selective (SS) HSI 90° pulse (Figure 1) tips the magnetization to the transverse plane. STEAM's 50% signal loss is avoided with a hard 180° at $\tau_1/2$ to refocus the magnetization and avoid the formation of a stimulated echo. A second HSI pulse at τ_1 stores *only* the magnetization in the VOI along *Z*. Outer volume suppression (OVS) is provided by a SLR 90°, exciting regions to the left and right of the VOI. Crushers then dephase all transverse magnetization from outside the VOI. Finally, the last HSI pulse subdivides the VOI in the 3rd direction and tips the magnetization back to the transverse plane where it is immediately detected as an FID. Suppression of extraneous magnetization excited by the 3rd pulse is accomplished by alternating the phase (0°,180°) of the 2nd and 3rd pulses between two measurements.

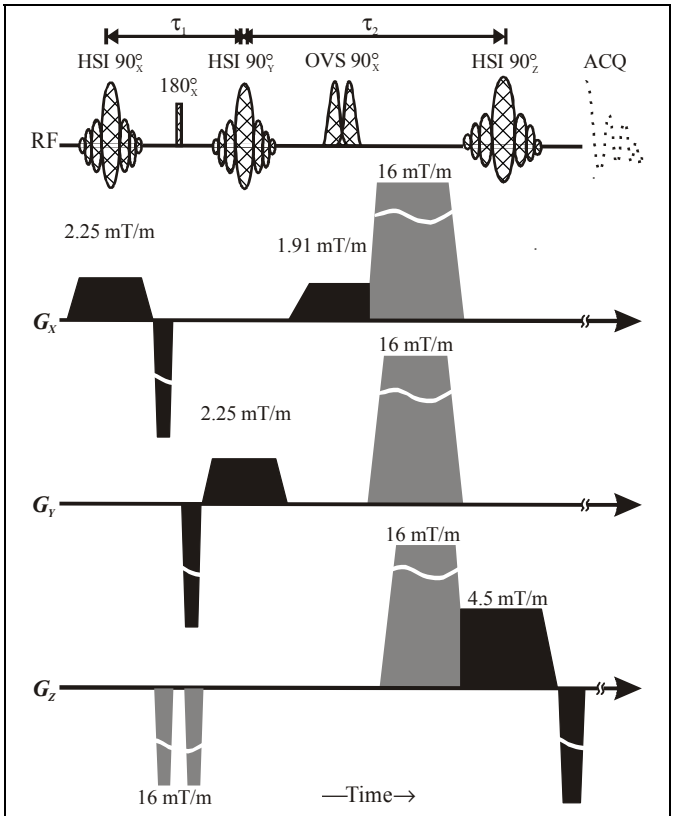

Figure 1: Sequence used. Note that a FID is acquired immediately following the last 90°

Methods and Results: The approach is demonstrated on the brain of a healthy female at 1.5T in a Magnetom Avanto (Siemens AG, Erlangen Germany) with its standard CP head coil. A VOI of 8×8×4 cm^3 (left-right (LR)×anterior-posterior (AP)×inferior-superior (IS)) was partitioned into 8×8×4 voxels with two 8th order HSI 8.2 ms pulses in the LR×AP directions and a 4th order HSI 8.2ms pulse in the IS direction. At TR=1.2s the 8×8×4×4=1024 encoding steps took under 21 minutes and the results are shown in Figure 2, along with the image of the brain for anatomical reference.

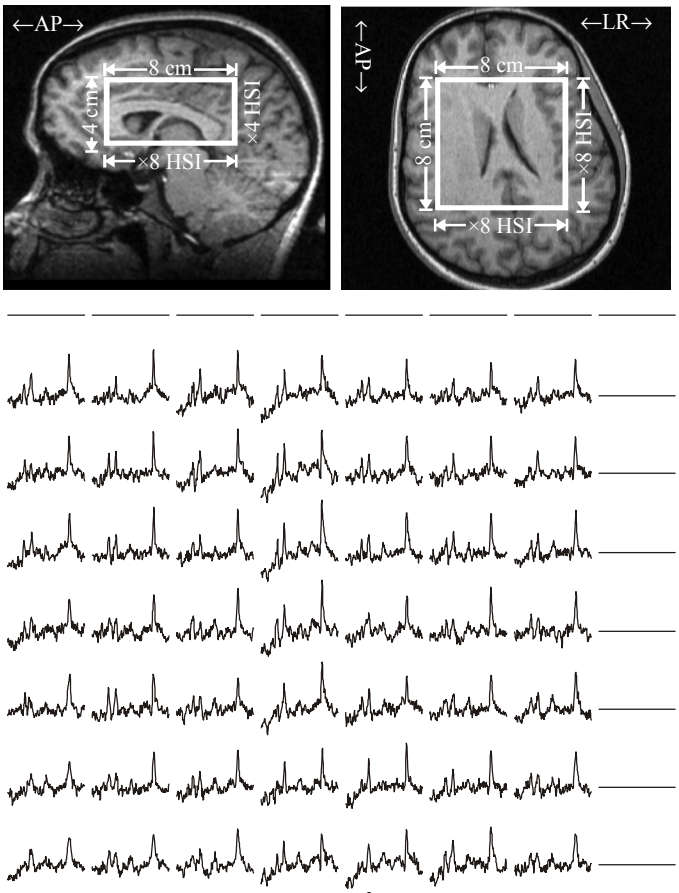

Figure 2: Spectra acquired from 1 cm^3 voxels in under 21 minutes from an axial slice

Discussion and Conclusions: A novel sequence is shown that acquires the full MRS signal with no echo time, avoiding T_2 losses or *J*-modulation. *In vivo* results show good localization and high SNR making it suitable for short T_2 or *J*-coupled metabolites.

References:

[1]Moonen et al., NMR in Biomed 1989
[2] Frahm et al, Journal of Computer Assisted Tomography 1991
[3] Goelman et al, Journal of Magnetic Resonance 1990
[4] Ogg et al, Journal of Magnetic Resonance, Series B 1994.