SPECTROSCOPIC LOCALIZATION BY SIMULTANEOUS ACQUISITION OF THE DOUBLE-SPIN AND STIMULATED ECHOES

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Target Audience: Scientists and clinicians involved in magnetic resonance spectroscopy (MRS).

Purpose: We present a new localization scheme for MRS, which combines the high signal to noise ratio of Point REsolved Spectroscopy (PRESS) with the low specific absorption rates, short echo times, small chemical shift displacements, high B_{1+} immunity and sharp localization associated with STimulated Echo Acquisition Mode (STEAM). The sequence is four step modification of the basic three pulse localization module (as used in, e.g., PRESS or STEAM), having angles α, β, γ (for simplicity, set $\beta=\gamma$): (i) the spoiling gradient moments are set at a 1:2:1 ratio; (ii) the inter-pulse delays are set at a 1:2:1 ratio to TE/4, TE/2, TE/4; (iii) The pulse's phases are set using the "CPMG phase relation", i.e. (0°, 90°, 90°); Conditions (i)-(iii) assure us the stimulated (STE) and double spin (SE) echo pathways are unspoiled and appear in phase, and hence the VOI signal is the sum $S=S_{SE}+S_{STE}$. Viewed as a function of η (the nominal B_{1+}; $\eta=1$ for no B_{1+} inhomogeneity), it is $S(\eta) = \sin(\alpha\eta)\sin^4(\beta\eta/2)+ \frac{1}{2}\cdot\sin(\alpha\eta)\sin^2(\beta\eta)$. By fixing α, we demand maximum B_{1+} immunity: $(dS/d\eta)_{\eta=1}=0$, which furnishes a numerical relation between α and β. The new approach is dubbed STRESS=STEAM+PRESS. Example: for $\alpha=100°$ (=STRESS-100), $\beta=\gamma=131°$ and S=0.95, 95% of the full spin echo signal. For $\alpha=110°$ (=STRESS-110), $\beta=\gamma=108°$ and S=0.83.

Methods: A 2D CSI (TR/TE=1000/40 ms, 20×20 acq. matrix), was run in a homogeneous phantom containing N-acetylaspartate (NAA) resonating at 0 Hz and Creatine, with a methyl resonance 240 Hz off-resonance, comparing PRESS to STRESS-110 using SLR-designed pulses with 1 kHz peak B_1. STRESS-110 was compared to PRESS in-vivo in a healthy female volunteer who provided IRB-reviewed consent using a 2D CSI supra-ventricular slice (TR/TE=1500/40 ms, 16×16 acq. matrix, 140×140 mm^2 in-plane FOV, 70×70 mm^2 VOI, 1.2 cm slice thickness).

Results: Phantom (Fig. 2): STRESS-110 showed 85% of the NAA SNR and 87% of the Cr-CH_2 SNR of PRESS, but with a 3-fold reduction in CSD in-plane. In-vivo (Fig. 3): STRESS-110 showed 87% of the NAA SNR and 88% of the Choline SNR of PRESS in the VOI, with the same 3-fold reduction in CSD observed in the phantom.

Discussion: Compared to PRESS, simultaneously acquiring two coherence pathways allows for improvements in CSD, B_{1+} immunity, minimum TE, SAR and voxel profiles by reducing the flip angles of all pulses, in return for a slight reduction in SNR. Care must be taken during quantification, however, due to the presence of two pathways undergoing different relaxation and J-coupling evolution. However, for short enough TE (<<1/J), both relaxation and J-coupling evolution will be minimized and quantification simplifies considerably.

Conclusion: A new localization sequence combining the spin echo ("PRESS") and stimulated echo ("STEAM") has been demonstrated, capable of providing STEAM-like performance with PRESS-like SNR.

References: [1] P. A. Bottomley, T. H. Foster, W. M. Leue, PNAS 81:6856-60 (1984). [2] J. Frahm, K. D. Merboldt, W. Hanicke, JMR 72:502-8 (1987)

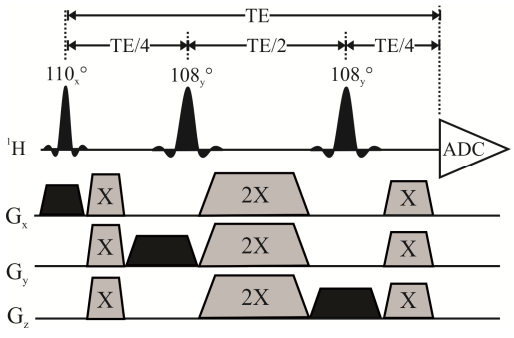

Figure 1. The STRESS pulse sequence.

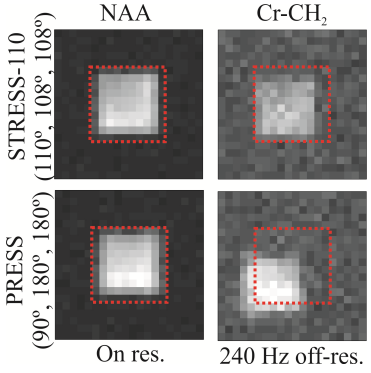

Figure 2. Phantom results: Metabolic maps of NAA (2 ppm, on resonance) and Cr-CH_2 (3.9 ppm, 240 Hz off resonance), for both PRESS and STRESS-110, showing 3-fold decrease in CSD for STRESS-110.

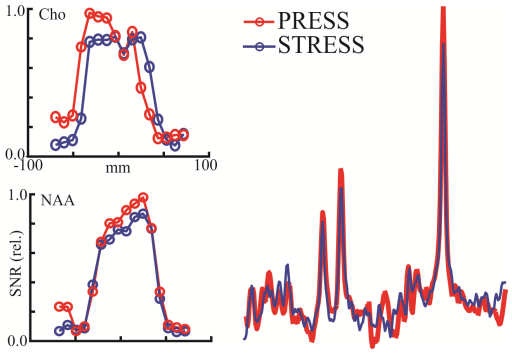

Figure 3. In-vivo results comparing PRESS and STRESS-110 at TE=40 ms. Left: SNR of Cho (top) and NAA (bottom) along a column of voxels from a supra-ventricular slice. Right: representative spectra from a slice from the VOI's center.