2D Arbitray Shape Excitation for Spectroscopy Measurement

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Introduction:

MR spectroscopy has tremendous potential providing biochemical information for animal and human studies. Most acquisition methods use PRESS or STEAM to selectively excite a cube volume from region of interest (ROI). Because of the complexity of the shapes of the in vivo tissues, the cube volumes being selected often have to be very small to fit into the interested tissue and avoid partial volume effect, which necessitates long averages to obtain sufficient signal-to-noise ratios (SNRs) and makes it difficult to be applied in many situations.

In this work we describe an approach using 2D arbitrary shape excitation pulse to select ROI and acquire a spectra. In general, the criteria of the quality of the local selective spectra are accurate volume selectivity, wide bandwidth, narrow line width and good water suppression. We also present the methods used to facilitate the spectroscopy acquisition corresponding to these criteria. Preliminary data on phantoms are demonstrated.

Methods:

The idea of 2D spatial selective excitation using RF pulses along with time-depended gradients started in 1989 (Pauly [1]). The excitation of a selected volume is to sufficiently sample the spatial frequency space, k-space, with chosen trajectories made by gradients and the accompanying RF pulse, which is the weighting function, proportional with the Fourier transform of the excited volume. We used echo-planar k-space trajectory for our 2D excitation pulses. In order to achieve both maximum accuracy and efficiency, RF pulses are only applied during plateau part of the gradients with ramps using the maximum slew rate (MSR), and the sample period (Δt) is made to minimize the time going through one k-space line, including both the plateau part and the two ramps along sides with it. At our 4T Bruker system with MSR=71 Gauss/cm/ms, the excitation pulse length (EPL) is 37ms to excite a 64*64mm FOV with 1mm^2 resolution.

In analogy with echo-planar imaging, the excited shape of echo-planar excitation pulse is distorted by B_0 field inhomogeneity and contaminated by the N/2 ghost caused by the time delay between the RF/gradient synchronization problems. We integrated conjugate phase correction method to correct the field inhomogeneity distortion effect (Schomberg [2]) and used balanced reference scan technique (Reeder [3]) to obtain the exact time delay without the dependence of the object. For the being measured metabolites, a series issue is the off resonance shift along the phase encoding direction (y), which equals to $\Delta y * EPL * f_{offset}$.

Interleaved excitation pulses (Panych [4]) are used to alleviate this constraint. But attention should be put on the increased demand on RF pulse to keep the maximum flip angle, which limits the number of interleaves to be used without compromising the desired SNR. Another issue is that interleaves will have discontinued phase evolution along phase encoding direction in the presence of off-resonance and so the resulted shape will be blurred. An incremental delay is put before the acquisition for each interleaves to get rid of the phase discontinuity. Interleaved excitation pulses will also improve the bandwidth by a factor equal to the number of the interleaves.

In order to achieve a narrow line width for the water spectra from the ROI, the basic spherical harmonic functions of the B0 field in that ROI are solved in both first order and second order, and then compensated through shim coils.

Water suppression is achieved by integrating MEGA (Mescher [5]) for the good B_1 insensitivity by $\cos^4(\theta/2)$.

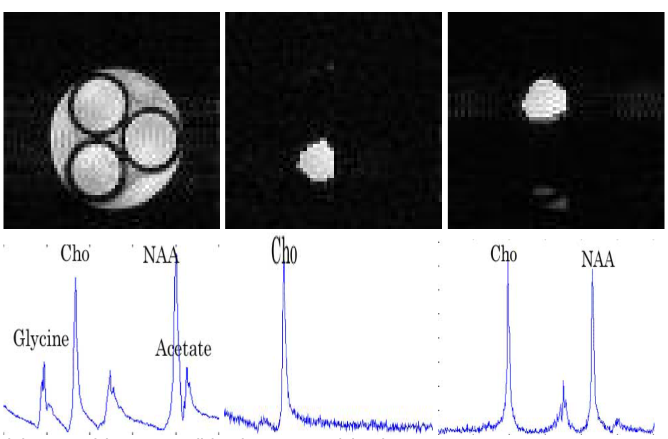
Results:

The pulse was tested on a phantom composed by a valve of 60mM NAA, a valve of 20mM Cho, a valve of both, and both 90mM Glycine and 60mM Acetate outside as bath solution (Fig. 1). ROIs were chosen as everything (a), a single valve of Cho (b), and a single valve of both NAA and Cho(c). Both the spatial selection and spectral selection are shown.

In Fig. 2, the off resonance behavior of the pulse is shown with the change of the increased number of interleaves. With the 8 interleave (EPL_8 =37/8=4.6ms) pulse we used for a 1mm resolution of 64 mm FOV, the spectral bandwidth of the RF pulse (a) was expanded to 600Hz and the spatial shift along phase encoding direction moved down to 2.8mm (b).

Conclusion:

The demonstrated spectroscopy acquisition using arbitrary shape excitation could be used in applications where those single cube volumes won't give sufficient SNR, with the careful consideration of all the off resonance limits.



(a) everything (b) Cho (c) Cho+NAA

Fig. 1. phantom study on spacial excitation (the first raw) and spectracl gradients(b)

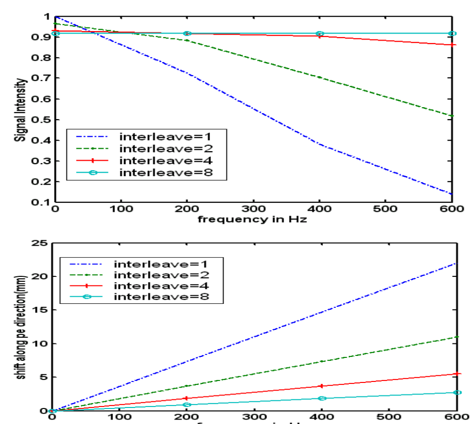


Fig. 2: Off resonance behavior of RF(a) and excitation (the second row)

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