Title: Accelerated Simultaneous Multi-slice MRS USING Hadamard-encoded Excitation and Sensitivity Encoding

Introduction: Hadamard-encoding has been used for simultaneous multi-slice excitation in both magnetic resonance imaging and spectroscopy [1]. To distinguish signals from the two excited slices, the phase offsets of the RF pulses need to be varied in two acquisition steps. Sensitivity encoding (SENSE) can reduce acquisition time by a factor of R by using spatial sensitivity information to unfold aliased pixels [2,3]. Here we propose a method that combines Hadamard encoding for multi-slice excitation with SENSE (R=2) to provide two-slices multi-voxel MR spectroscopy without increasing total acquisition time.

Method:

Hadamard-encoded excitation applies two set double-band excitation pulses, where the first set RF pulses excite two bands with same phase (++) and the second set with opposite phase (+-). After acquisition, echo1+echo2 will get left band signal and echo1-echo2 for the right band. The pulses we used are shown in Fig 1a, with pw=4ms, excitation thickness=1cm, and separation=3cm. We tested the pulses on phantom at 3T scanner.

Hadamard double-slice excitation pulses were implemented in PRESS in the SI direction while SENSE was applied for in-plane sampling[4]. The center of Hadamard pulses is put at the center of phantom with slice thickness is 1.5 cm. As a result, the distance between two excited bands is 3x1.5x1.2=5.4cm along SI direction.

We acquired box image with Hadamard excitation and single-slice excitation individually, as well as single voxel spectra. For all scans, TR/TE = 1200/35 ms. For Hadamard SENSE 2D MRS, matrix size is 20x10, where frequency-encoding along RL direction, under-sampling phase-encoding in AP direction, and total acquisition time is about 8 min.

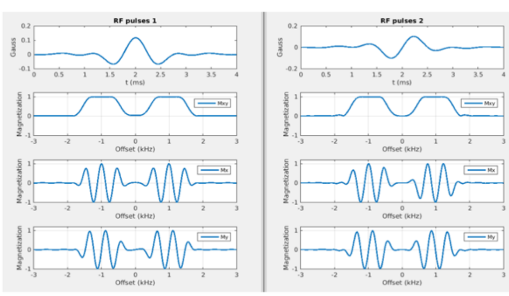

Fig 1a

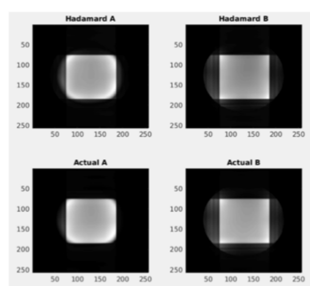

Fig 1b

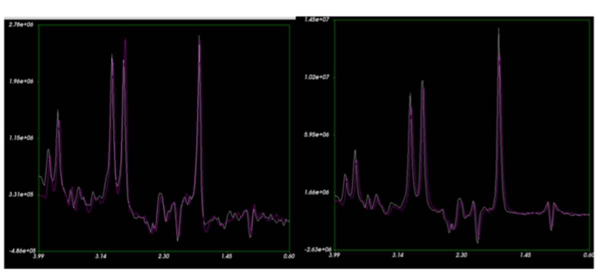

Fig 1c

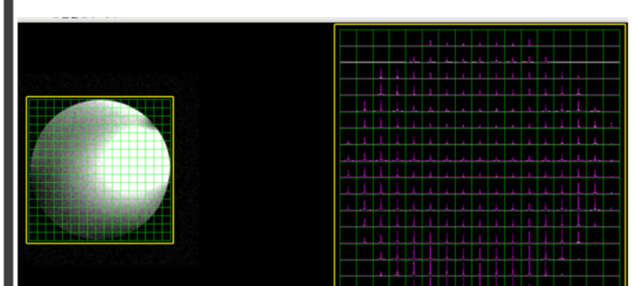

Fig 1d

Result:
Hadamard reconstructed image and actual acquired image from the phantom are given in Figure 1b. Two slices of a phantom are simultaneously excited, with one located in the top of he phantom and the other in the center of the phantom. The reconstructed images are similar to those acquired images at the same location.

Fig. 1c shows comparison between Hadamard reconstructed and actual acquired single-voxel-spectra (SVS). The left side is SVS located in the top of the phantom, and the right side represents bottom location, with actual acquired in the and Hadamard reconstruction in red. Both spectra demonstrate good similarity.

Fig. 1d demonstrates 2D MR spectroscopic imaging reconstructed from the data acquired using Hadamard and SENSE encoding.

Conclusion:
The preliminary data using Hadamard and SENSE encoding demonstrated good data quality. At the next step, we will apply the methods in healthy controls.

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References:
1. Souza SP et al. Comput Assist Tomogr. 1988 Nov-Dec;12(6):1026-30.
2. Pruessmann KP et al. Magn Reson Med. 1999 Nov;42(5):952-62.
2. Ozturk-Isik et al. Magn Reson Med. 2006 May;55(5):1164-9.
3. Li Y et al. Magn Reson Imaging. 2006 Dec;24(10):1295-302.