Multiband MR spectroscopic imaging in human brain

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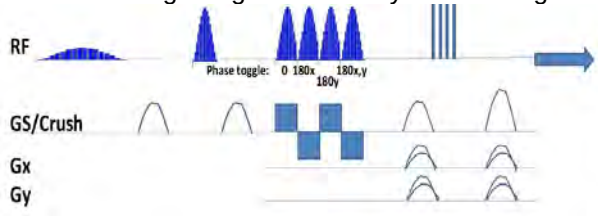
Target audience: MR scientists and application specialists

Introduction: At 3T, 3D spectroscopic imaging studies are often limited by chemical shift dispersion errors (CSDE) due to limited RF strength from the body coil used for transmission. This occurs for both in-plane and slice selection directions. While the in-plane artifact can be eliminated using a non-selective inversion recovery sequence, Hadamard encoding can be used to minimize the artifact in the slice direction since this method allows for multiple narrow slices to be acquired simultaneously with minimal CSDE. However, to acquire n separate slices, Hadamard encoding requires n separate acquisitions, thus lengthening scan times and effectively limiting in-plane resolution. To overcome this limitation we have developed a multi-band (MB) MRSI sequence that provides the CSDE advantages of Hadamard while eliminating the need for multiple acquisitions to deconvolute the overlapping slice data.

Methods: All data were acquired at 3T using a 32 channel receive only array and body coil transmission using the sequence in Fig 1. To minimize contamination, the phase of the four slice selective excitation pulses were shifted by 180° depending upon the value of the in-plane encoding step, kx and ky to distribute the data in both phase encoding directions and minimize overlap (similar to the single dimension approach used by CAIPIRINHA). Using this method 93% of the pixels are either not overlapped by any other slice (green region Fig 1) or overlapped by a single slice (yellow region). The data was reconstructed using the sensitivity matrix of the receive array. As implemented at 3T, the data are acquired using a MB factor of 4, a non-selective inversion pulse to retain the cortical periphery and eliminate in-plane CSDE effects, and 24x24 encodes over a FOV of 240mmx240mm using TR/TIR/TE of 2000/210/50ms, acquisition time 19min. Data were acquired from 5 control subjects, 5 epilepsy patients and a tumor patient. Bolero B0 shimming was performed over the regions of interest using 1st and 2nd degree shim terms. Metabolically abnormal regions were automatically identified using a regression analysis including the effects of gray and white matter inclusion in the measured pixels.



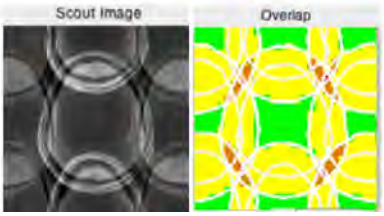
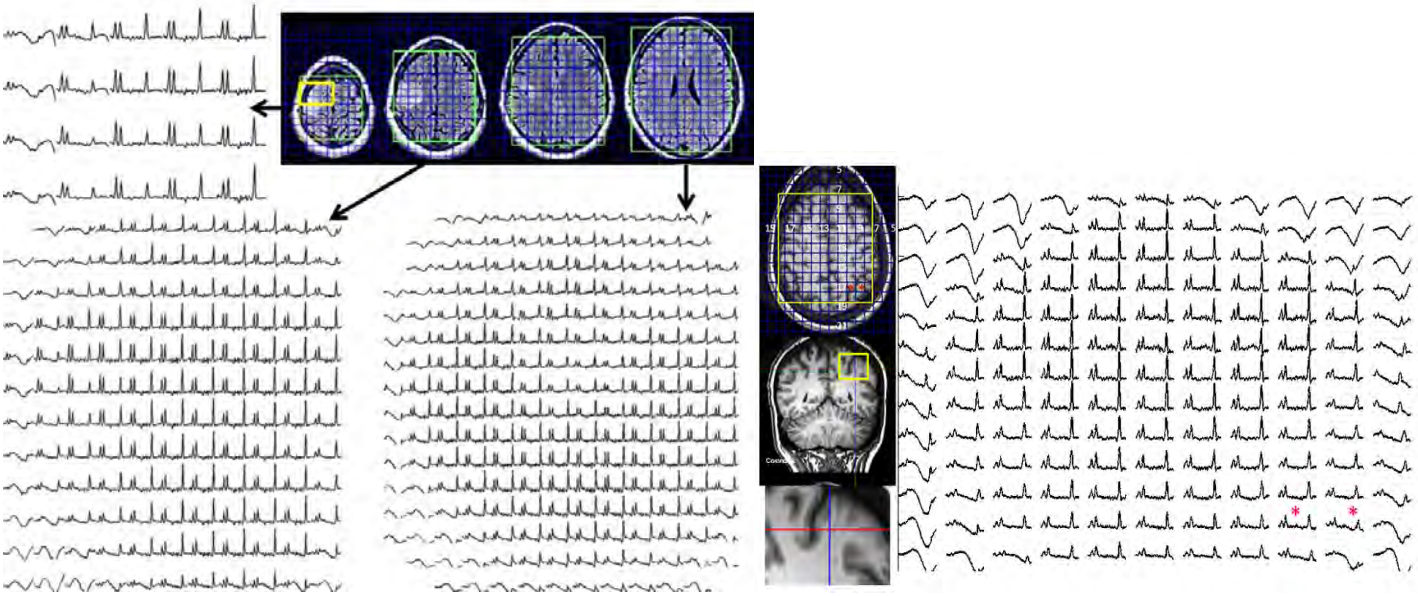


Fig. 1: Pulse sequence, slice selective pulses are cycled 0/180 depending on kx,ky. Scout image - overlap of slices. Overlap image - green no overlap (25%) yellow 2 slices (68%), brown 3 slices (7%) red all slices overlap (0%).

Results: Fig 2 displays spectral data from a tumor patient. Within and anterior to the FLAIR hyperintense region there is a large increase in Choline (Ch) relative to NAA and Creatine (Cr) consistent with tumor progression. Fig. 3 shows data acquired from an epilepsy patient. In this example the reduction in NAA relative to Cr and Ch corresponded to a subtle dysplastic lesion identified retrospectively in the high resolution ($1mm^3$) MPRAGE.

Fig. 2 Fig. 3



Conclusions: The MB sequence minimizes CSDE effects in both the in-plane and slice selection direction. A factor of 4 acceleration in acquisition speed, with minimal contamination was achieved by distributing the data in two directions and is enabling robust moderate echo CSI acquisitions at 3T with coverage reaching the neocortical edge.