Improved Spectral Resolution in 2D Localized Correlated Spectroscopy Using Enhanced Covariance NMR

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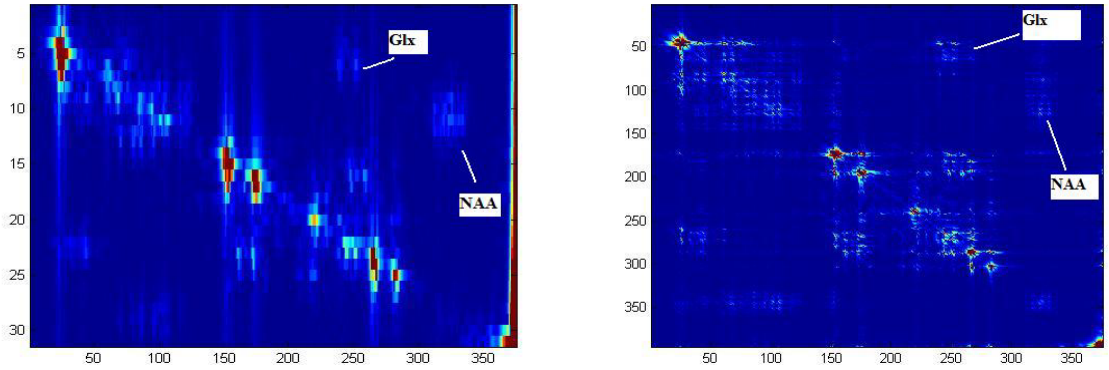
Introduction: Different versions of two-dimensional (2D) localized correlated spectroscopy (L-COSY) have been implemented and pilot evaluations show improved resolution of spectral peaks compared to one-dimensional (1D) MRS (1-2). A major drawback of 2D MRS in vivo approaches so far is due to the long acquisition duration dictated by the number of incremental steps which are used to achieve the 2nd spectral dimension. Recent implementation of a covariance NMR method in high resolution NMR shows clearly that equal resolution can be achieved along the two dimensions even though the indirect dimension has few points only (3,4). A major goal of this project was to implement covariance NMR in processing the L-COSY data while using limited indirect dimension points.

Materials & Methods: A 3T Trio-Tim MRI scanner equipped with a bitemporal 4-channel phased-array coil was used for this investigation. Several phantoms with metabolites at higher and physiological concentrations were tested using the covariance NMR based transformation. 2D L-COSY spectra were recorded in the occipito-parietal gray/white matter region of eight healthy human subjects and phantoms using the following parameters: TR/TE=2s/30ms, 100t1 increments for the 2nd dimension, 2048 complex points for the detected t2 dimension, 8 averages per t1 increment and 3x3x3 cm3 voxel. A reduced data set (2048x64) was taken from the original 2048x100 data set for further processing. The raw data was filtered using a skewed squared sine bell filter and Fourier transformed along the direct dimension, yielding a series of 1D spectra time shifted in the indirect dimension. Covariance matrices of size 2048x2048 were constructed from the real and imaginary parts and combined to form a magnitude covariance matrix. A control matrix was formed from the diagonal elements of the magnitude covariance matrix multiplied by a phase shift factor, such that each row of the control matrix is a 1D spectrum (4). A reference covariance matrix was computed from the control matrix. Element-by-element ratios of the magnitude covariance matrix to the reference covariance matrix were taken, and indices whose values were below a threshold of 10 were noted. The corresponding values in the covariance matrix were zeroed, and the result was plotted.

Results and Discussion: Shown in Figure 1 are 2D L-COSY spectra of a brain phantom containing 16 metabolites. The acquired matrix size of 2048x100 was double Fourier Transformed in Figure 1A. The acquired matrix was reduced to 2048x64 and represented as a covariance matrix in Figure 1B. Demonstrated in Figure 1B is the improved spectra resolution in the t1 dimension despite using only 64 t1 points, resulting in a total time 36% less than the that of the acquired data. We have evaluated in vivo 2D L-COSY spectra using the same methods, demonstrating improved spectral resolution and decreased acquisition time.



A. **B.**

Figure 1: 2D L-COSY Spectra processed using A) 2D FFT (2048x100). B) Covariance Matrix (2048x2048).

Conclusion: Our preliminary results demonstrate that covariance NMR method can be extended to process the 2D L-COSY data with a matrix size of 2048x64 without affecting the overall quality of a 2D spectrum. A major advantage of this novel methodology is that equal resolution can be obtained along both dimensions

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