Rosette Spectroscopic Imaging with Hadamard Encoding

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TARGET AUDIENCE

Researchers and clinicians interested in fast spectroscopic imaging (SI) and automated processing of SI data.

PURPOSE

Requirements for achieving simultaneously proper K-t space sampling, highest SNR sensitivity, and fastest acquisition for the rosette trajectories in a SI experiment for a given spatial resolution and spectral width (SW) have been previously described [1]. By combining the fast RSI acquisition technique with a Hadamard [2,3] encoding scheme, one could achieve SNR sensitivity gains and desirable excitations profiles.

METHODS

A cascaded Hadamard excitation scheme, encoding 4 slices, was implemented for *in-vivo* brain SI. Two inversion pulses were used for lipid/water suppression (TI=240/950ms), and the echo/repetition time were TE/TR=40/2000ms. A frequency refocus pulse was used to selectively refocus the resonances of interest. Data was collected in an epileptic female patient, using a 32-channel head coil on a Siemens (Siemens, Erlanger, Germany) 3T MR scanner. The rosette trajectories were designed for a 24x24 acquisition, field of view fov=24cm, SW=1300Hz, with reduced gradient demands: a maximum slew rate of 40mT/m/ms and a maximum gradient strength of 5mT/m were used. The number of shots required to fully sample K-t space is Nsh=38 shots. To achieve higher SNR, instead of averaging, the number of spatially interleaved shots used was increased to NshUsed=60 shots, for a total acquisition time of 8minutes (4x60x2s). For each shot, the readout duration was 300ms, with an ADC sampling rate of 10us. A water reference scan was also acquired in 1:36min:sec, with a flip angle FA=20 degrees and TR=400ms. Data for each channel was reconstructed individually, using a two-fold gridding matrix [4], and the water reference scan was used for Eddy current correction and channel recombination. A Hamming window was applied, and data was reconstructed to a 32x32 matrix. Programs in Matlab were developed to pass reconstructed data to LCModel [5,6], for automated phasing, fitting and metabolite quantification, and to read the LCmodel output for all voxels (phase-corrected, baseline, metabolite concentrations and ratios, Crammer-Rao Lower Bounds (CRLB), etc). Spectra were processed in the interval 4.0-0.2ppm and SNR for tNAA (NAA+NAAG), tCr (total Creatine Cr+PCr), tCho (total Choline) was calculated as peak intensity divided by standard deviation (SD) of the noise in a metabolite free region (0.2-0.5ppm), using the phase-corrected, baseline-subtracted LCModel calculated spectra. Point spread function (PSF) was simulated and full width/volume at half maximum (FWHM/FVHM) was calculated [7].

RESULTS

CRLB maps for tNAA are shown in Fig 1. For the 4 slices acquired, there were a total of N=845 voxels which had CRLB<20% for all three metabolites considered (tNAA, tCr, tCho). Maps for tNAA, for the four slices, generated using the concentrations calculated by LCModel are shown in Fig 1. Average raw SNR (for the N=845voxels) was 52, 28 and 22 for tNAA, tCre and tCho, respectively. Mean CRLB values were 5.18% (tNAA), 7.78% (tCre) and 9.67% (tCho). FWHM and effective voxel size FVHM are only 5% and 7% larger for RSI than for conventional phase encoded CSI with square support. Examples of the LCModel processed spectra (phase-corrected and baseline-subtracted) for the region shown as a green box in Fig 3, overlaid on a FLAIR image for one of the slices, are shown in Fig 4.

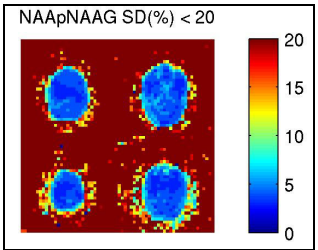

Fig 1:. *tNAA CRLB maps*

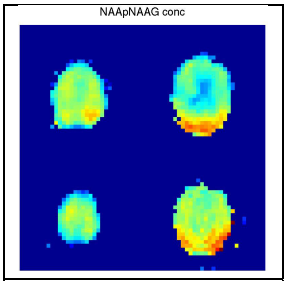

Fig 2:. *tNAA conc maps. Voxels with CRLB>20% were masked.*

DISCUSSION AND CONCLUSIONS

Rosette Spectroscopic Imaging (RSI) with Hadamard encoding is a fast acquisition technique. While due to the lipid inversion pulse used, the SNR sensitivity is not as high as for the LASER/PRESS encoding techniques, it has the advantage that spectral information can be collected close to the scalp, in regions like the prefrontal cortex area, for example. Furthermore, by implementing a ring lipid supression scheme as in [10], and/or using a higher field strength (e.g, 7T), the SNR penalty incured due to the lipid inversion pulse applied, can be eliminated. The higher spectral width needed at higher fields, necessary to resolve all resonances, can be attained much easier with rosette trajectories than with other fast acquisition techniques using gradient readout [1,9].

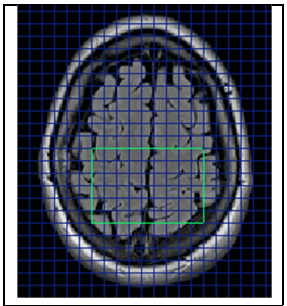

Fig 3:. *FLAIR image coresponding to one of the RSI slices. Green box represents a user selected ROI, for which to display spectra (Fig 4)*

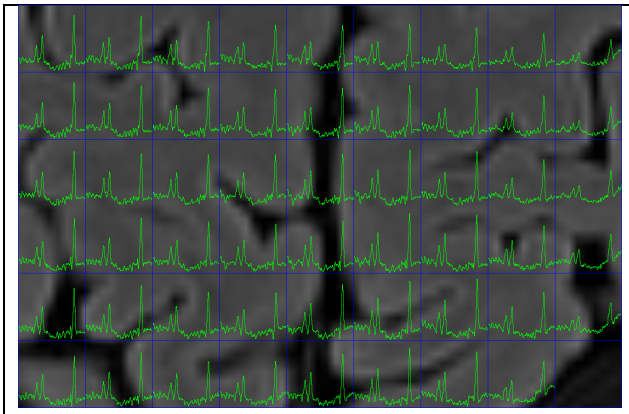

Fig 4: *Examples of LCModel processed, phase-corrected, baseline-subtracted spectra, for the green box ROI in Fig 3.*

REFERENCES: [1] Schirda *et al.*, JMRI '09;
[2] Bolinger, JMR '88;
[3] Gonen *et al*., MRM '97;
[4] Jackson *et al*., IEEE Trans Med Imag '91;
[5] http://www.s-provencher.com/pages/lcmodel.shtml;
[6] Provencher, MRM '93;
[7] Zierhut *et al*., JMRI '09;
[8] Hetherington *et al*., MRM '10,
[9] Schirda *et al*., ISMRM 2014.