Abstract 45419

B0 field Mapping to improve prior knowledge in quantitative 2D-MR Spectroscopy

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Purpose / Introduction

Recent studies (1,2) have demonstrated that quantitative 2D-MR-Spectroscopy (Q-2DMRS) provides an enhancement of the accuracy of metabolite concentration estimation. This is especially interesting when the spectral dispersion is limited by the magnetic field strength (≤7T). However, from the quantitative point of view, the information gain with the unraveling of the F1 dimension is limited by the increased number of parameters to estimate. In this work, to lower the number of parameters, we validate on phantom measurements the incorporation into our 2D spectroscopic signal model of a prior knowledge on T_2 inhomogeneity (T_{2inhom}), obtained from a B0 field map, and demonstrate via the Cramér-Rao Theory how Q-2DMRS performances are improved.

Subjects and Methods

Acquisition: Two 2D-MRS sequences involving different relaxation time weightings along the two spectroscopic dimensions were implemented on a 4.7T-Bruker-Biospin magnet: Localized CT-COSY (3) and JPRESS (4) (Figure 1).

$$\hat{s}_{2D\text{-}MRS} = \sum_{m}^{M} c_m \hat{x}_m(t_1,t_2)\, f_1(t_1,t_2,T_{2inhom},T_{2m})\, f_2(t_1,t_2,\Delta\omega,\phi_0)$$

$$f_1 = \begin{cases} \exp(-\frac{t_1}{T_{2inhom}})\exp(-\frac{t_2}{T_{2m}})\ \exp(-\frac{t_C}{T_{2m}}), \text{ for L-CT-COSY with a constant time tc=70ms} \\ \exp(-\frac{t_1}{T_{2m}})\exp(-\frac{t_2}{T_{2m}}), \text{ for JPRESS} \end{cases}$$

and using $\frac{1}{T_2^*} = \frac{1}{T_{2m}} + \frac{1}{T_{2inhom}}$,

Model 1 : $\frac{1}{T_{2inhom}}$ is estimated, **Model 2 :** $\frac{1}{T_{2inhom}}$ is a priori known from measured $\int_{voxel} \gamma\Delta B_0$

Figure 1 : model functions for Localized CT-COSY and JPRESS: where M is the number of metabolites, $\hat{x}_m$ the simulated metabolite 2D signals, with concentration c_m (parameters of interest). f_2 accounts for frequency shifts and zero-order phase.

The phantom consisted in an admixture of 9 metabolites in low melting 2% agarose gel. The B0 field map is constructed from a 3D-double gradient echo dataset with phase difference calculation, and subsequent phase unwrapping (FieldMAP). $1/T_{2inhom}$ estimation was obtained by integrating the B0 map over the MRS voxel. The measurements were performed three-times. Relaxation times were fitted for the main singlets (Figure 2). **Simulation:** Cramér Rao lower Bounds (CRBs) were calculated using the two JPRESS models described in Figure1, using typical in vivo concentrations, and simulated 2D metabolite signals.

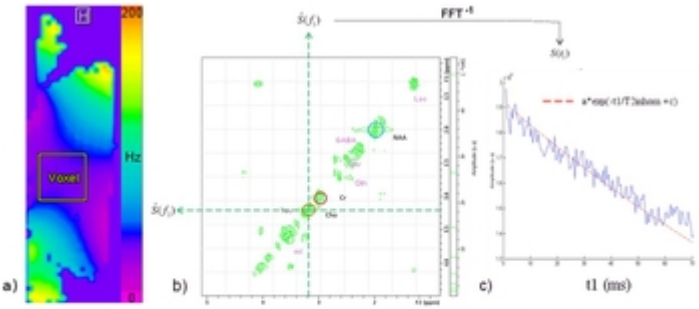

Figure 2: a) B0 field Map and MRS voxel localization b) L CT-COSY Map for a phantom of 9 metabolites (50mM concentration for NAA, Creatine, myo Inositol, Glutamate, Glutamine, Lactate, Taurine, GABA and 15mM for Choline), acquired with VAPOR water suppression, Tacq=15min, te=70ms, TR=3500ms, SW1=3500Hz, SW2=2000Hz. c) fit of the T_{2inhom} along the indirect dimension, on the Choline singlet extraction

Results

On figure 3, as expected CRBs on metabolite concentrations are lower for Model 2. On Table 1 are reported the measured and extrapolated values for T_2 and T_{2inhom}. Good concordances were found between these values validating the use of B0 field map prior knowledge in the model function.

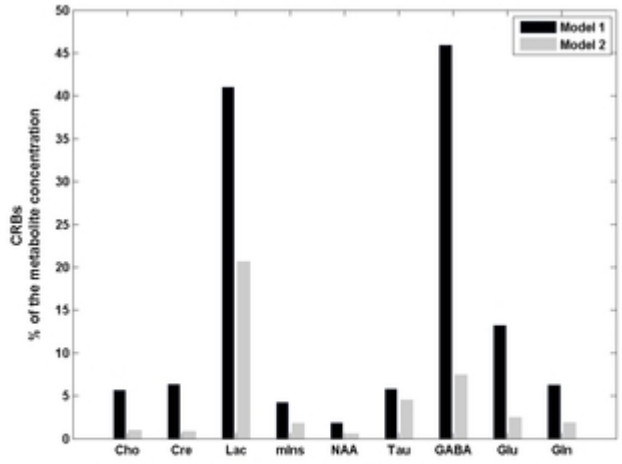

Figure 3 : CRBs on JPRESS metabolite Concentration Estimation without (Model 1) and with (Model 2) priorknowledge on T_{2inhom}

		JPRESS	CT-COSY	FieldMAP
$T2_{inhom}$(ms)	Exp I	239.9 ± 9.7 %	243,4 ± 9.4%	257,7
	Exp II	225.7 ±4.3 %	212,4 ± 10.6%	214,6
	ExpIII	305.3±9.2%	301.5±4.8%	307.7
T2 (ms)	NAA	65.6 ±13.9%	66,6 ±8.5%	
	Cre	71.8±3.4%	69.2±15.7%	
	Cho	147.5± 3.4%	145.4 +9.5%	

Table 1 : Results (mean±RSD) for Relaxation Times extrapolation (using 1/T2*=1/T2inhom+1/T2, in light gray background) or directly fitted (in dark gray background) on JPRESS and CT-COSY measurement for a phantom of metabolite in agarose 2%. In this case, T_2 are found far shorter (for NAA and Cr) than in vivo and $T2_{inhom}$ far greater, inverting the role of these terms in the apparent T2*. T2inhom are averaged on the estimated/extrapolated values measured on the 3 metabolite singlets and are given for three different measurements. T2 values are averaged over the three measurements.

Discussion/Conclusion

The B0 field map information- which is almost systematically acquired during the shimming procedure for MRS measurement- can be used advantageously to reduce the number of parameter to estimate leading to a better conditioned 2D-MRS spectral fitting procedure. The proposed method will be evaluated in vivo, for the different 2D-MRS sequences. It is expected that, in vivo, the intra-voxel microscopic field inhomogeneity not pictured by the B0 field map will occur but will be averaged within the macroscopic MR spectroscopy voxel.

References

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