SRSLY
Sensitivity Resolved SubvoxeL sepctroscopY

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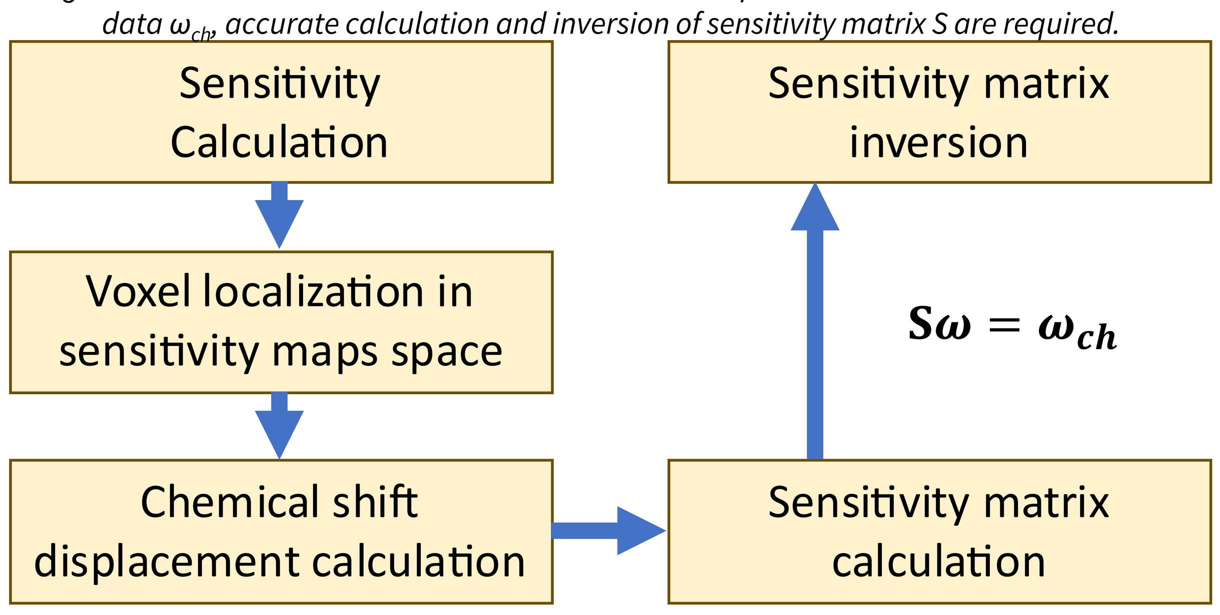
Introduction

Magnetic resonance spectroscopy (MRS) localization methods rely on combination excitation or refocusing radiofrequency (RF) pulses with gradients in three orthogonal directions. This allows selection of an approximately rectangular voxel the resulting spectrum originates from. Biological tissues on the other hand are not localized within a rectangular volume, leading to several tissues being included into every voxel. This, in turn, leads to contamination of the acquired spectrum with tissue and metabolite peaks from outside the target brain region.

Methods

The problem of untangling the signals occurring at the same frequency, but originating from different spatial locations, has been successfully solved in parallel MR-imaging via SENSitivity Encoding (SENSE[1]) method. Here, the possibility of SENSE-like spectrum recovery from different regions within a voxel using muti-channel MRS data is explored (Fig. 1), thus attempting **S**ensitivity **R**esolved **S**ubvoxe**L** spectroscop**Y** (SRSLY).

Fig. 1 SRSLY workflow. To recover individual subvoxel spectra ω from mixed multichannel data ω_{ch} accurate calculation and inversion of sensitivity matrix S are required.



To test SRSLY in simulation, 32 single-slice gaussian sensitivity profiles were generated. Two regions of interest (ROI) were defined in the same slice, and each was attributed a multicomponent spectrum. Per-channel noisy spectra from two ROIs combined were calculated using the synthetic sensitivity profiles. The resulting multi-channel simulated data was subjected to SRSLY reconstruction to yield individual ROI spectra (Fig. 2).

To test SRSLY experimentally, a phantom was made containing layered vegetable oil and water-ethanol mixture. It was scanned in a 3T scanner (Siemens Healthineers, Prisma) with 64-channel (52 channel active) head RF coil. Imaging was done with a gradient echo sequence using 1-mm isotropic resolution in a 160x160x120 mm^3 field of view with TE/TR = 4/10 ms and no acceleration. PRESS[2] (TE/TR = 20/3000 ms, NA = 1) was used for MRS within a 20x20x20 mm^3 voxel centered on the border between oil and water. Imaging data was used to calculate per-channel sensitivities using BART[3], and then to segment water and oil-containing parts of the voxel. Sensitivities and PRESS spectra were then used with SRSLY to yield subvoxel spectra from oil and water parts of the voxel (Fig. 3).

Results

Spectral simulation produced 32 per-channel spectra with overlapping spectral lines from different ROIs. SRSLY reconstruction with the simulated sensitivity profiles allowed accurately resolving every spectral line for each of the ROIs (Fig. 2).

3T PRESS spectrum of two-layered phantom exhibited multiple overlapping lines with multiplets at 1 ppm, and 3 ppm potentially attributed to ethanol, peaks between 1 ppm and 3 ppm attributed to fatty and carboxylic acid protons, peak at 4.6 ppm attributed to water, and a peak at 5.3 attributed to olefinic protons[4]. SRSLY reconstruction demonstrated substantial, although incomplete separation of spectra from oil and water subvoxels (Fig. 3).

Fig. 2 Simulated spectra and individual ROI spectra resolution with SRSLY

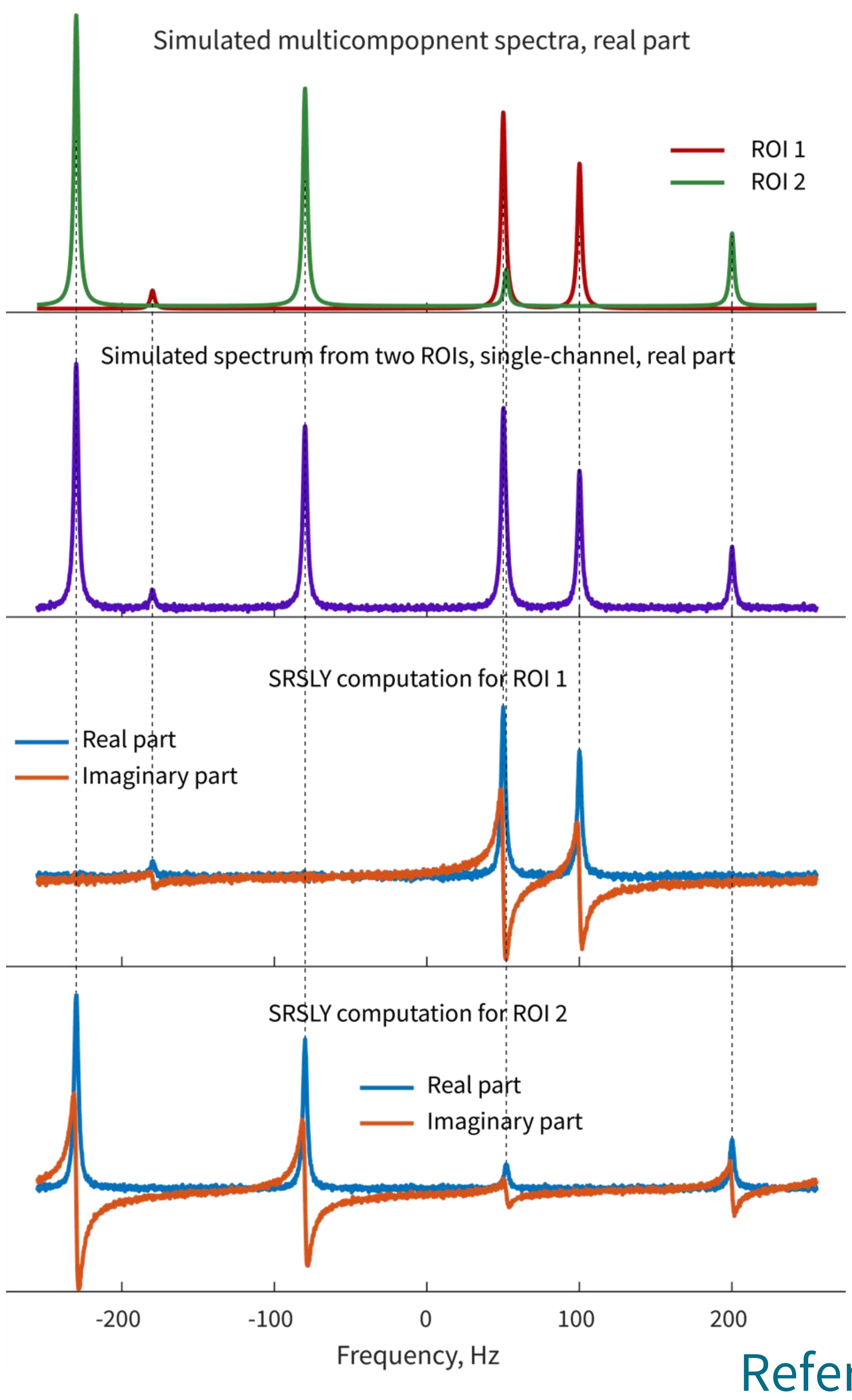
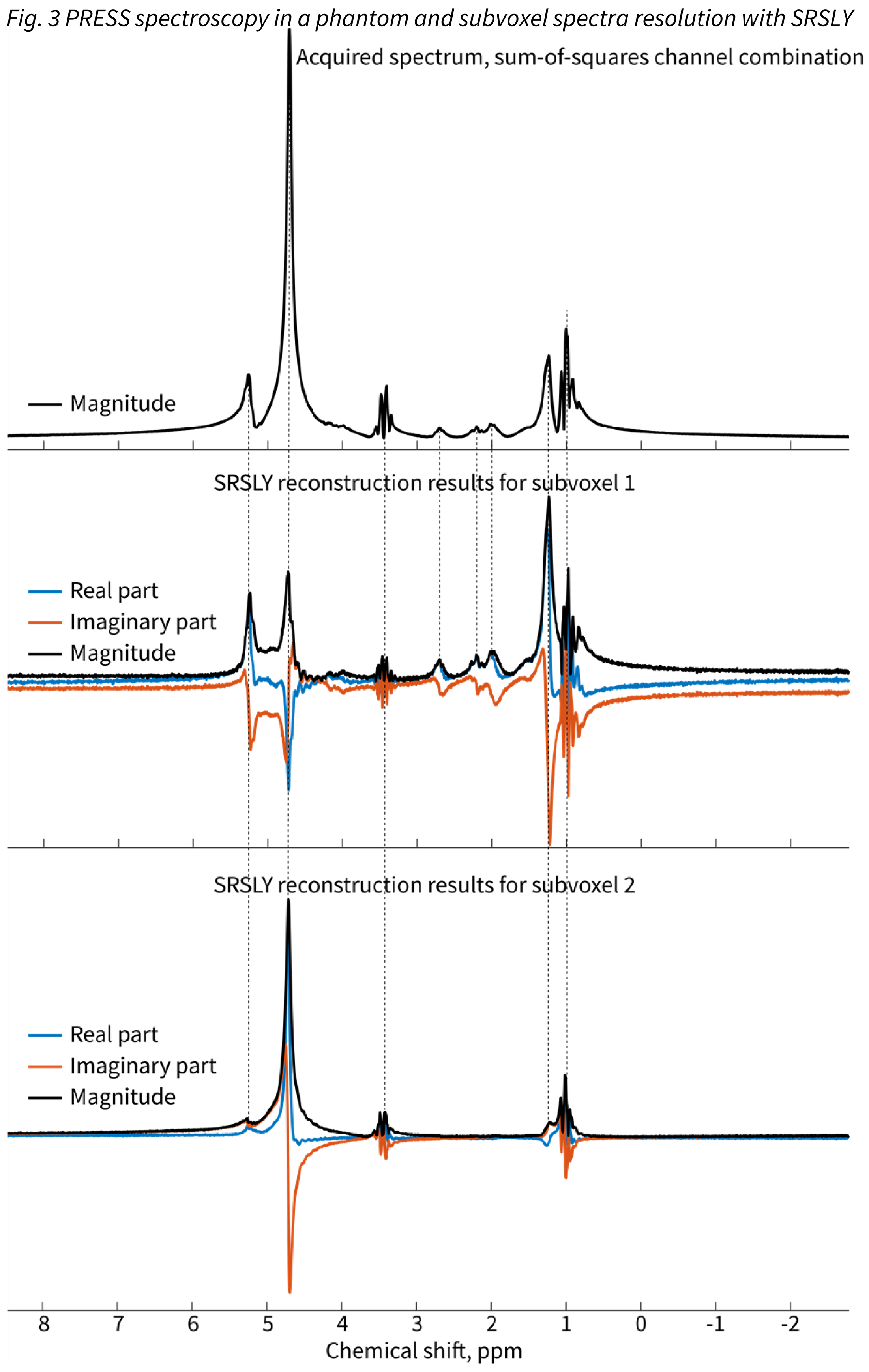


Fig. 3 PRESS spectroscopy in a phantom and subvoxel spectra resolution with SRSLY



Discussion

Simulated and experimental data suggests the feasibility of the subvoxel spectral separation from multichannel data. Simulations demonstrate higher fidelity of component separation even in the presence of noise. Potential sources of incomplete separation in the experimental data include: errors in voxel localization, in subvoxel segmentation or in sensitivity calculation.

SRSLY can help improve existing MRS techniques by removing CSF signal from within a voxel, allowing arbitrary-shaped voxels or performing localized MRS-imaging.

References

1. Pruessmann KP, et al. Magn Reson Med. 1999;42(5):952-962.
2. Bottomley PA. Ann N Y Acad Sci. 1987;508(1):333-348.
3. Uecker M, et al. Magn Reson Med. 2014;71(3):990-1001.
4. Reda SY, et al. Publicatio UEPG 2006;12(02).

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