In vivo Single Voxel ^{1}H MR Spectroscopy with Segmented 2D-Selective RF Excitations

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Introduction

Localisation in proton single-voxel spectroscopy is usually achieved by successive excitation of three orthogonal slices, generating the signal from a cuboid shaped intersection volume. To avoid partial volume effects, excitations that better match the underlying anatomic or pathological structure are useful. This can be realized using two-dimensional spatially selective RF pulses (2DRF) [1]. Due to the accumulation of phase errors along the excitation train standard 2DRF pulses usually offer poor off-resonance performance which leads to strong chemical shift displacements. Since single-voxel MR spectroscopy relies on the averaging of multiple acquisitions this problem can be solved by segmentation of the 2DRF as has been demonstrated in cardiac ^{31}P MRS and on phantoms [2,3]. The aim of this study is to test and demonstrate the feasibility of single-voxel spectroscopy with 2DRF using a blipped planar trajectory for in-vivo MRS of the human brain.

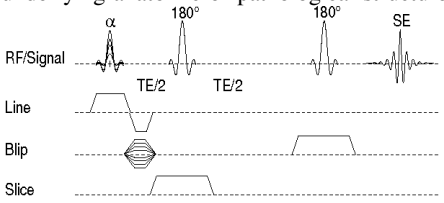


Figure 1: Basic pulse sequence for 2D-RF MRS

Methods

The basic pulse sequence is shown in Fig. 1. To minimize chemical shift displacement, each segment consisted of a single line of the trajectory. To ensure that the low flip angle approximation holds, a flip angle of 30° was used for the 2DRF. The second slice-selective refocusing pulse allows to reduce the side excitation distance, i.e. the number of necessary lines, while keeping the same spatial resolution. This method also decreases spurious water contamination from outside the voxel. The sequence was tested on a phantom composed of a cylindrical bottle of 100mM N-acetylaspartate with 30mm ∅ which was inserted into a larger bottle containing 80mM creatine (Fig. 2a). The experiments were performed on a 3T whole-body MR system (Siemens Magnetom Trio) using a short echo time of 30ms. Water suppression was achieved by three preceding CHESS pulses. The 2DRF trajectory was designed to obtain a profile sharpness of 5mm and a side excitation distance of 85 mm in phantom experiments and 45mm *in vivo* covering 17 and 9 lines, respectively. Spin-echo imaging sequences were modified, to acquire images of the profile excited by the selected 2DRF.

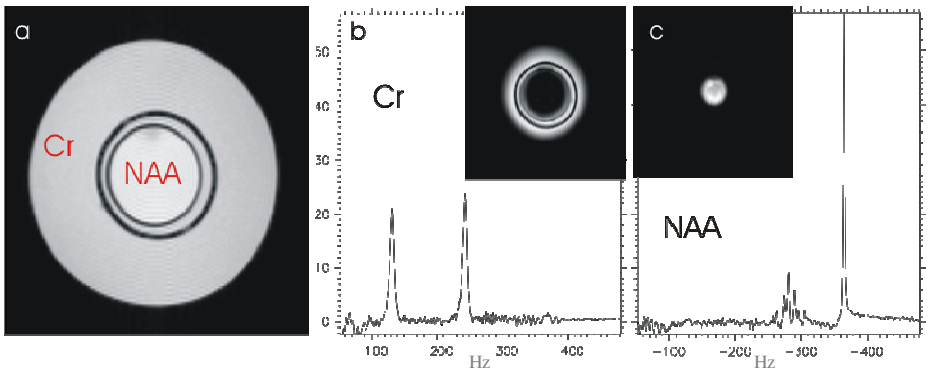
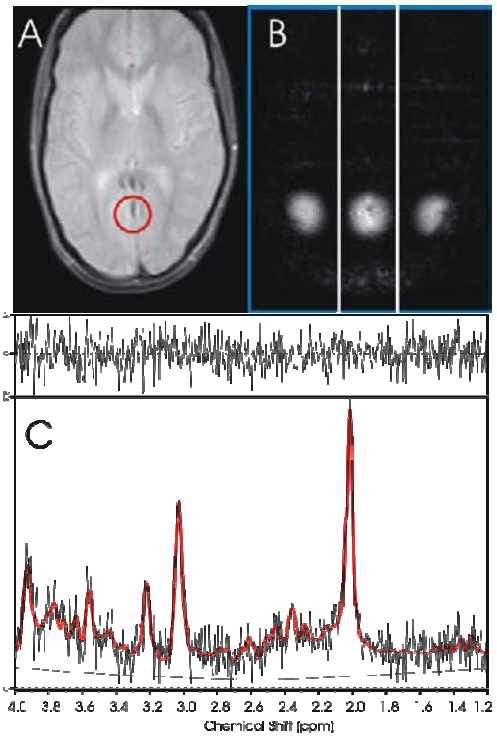


Figure 2: (a) Phantom containing NAA in the centre, Cr in the surrounding part. (b) Spectrum of a ring-shaped (35/65mm) excitation containing only Cr. (c) Spectrum of a cylinder-shaped (25mm) excitation containing only NAA.

Figure 3: Spin-echo image acquired (A) without and (B) with 2DRF excitation. The side excitations in (B) are suppressed in the MRS sequence. The corresponding spectrum is shown in (C).



Results and Discussion

To demonstrate the good localisation quality, two spectra were measured in the phantom. For the first spectrum a ring-shaped volume with 35/65 mm diameter (25mm thickness) was excited, only showing the signal of the surrounding Cr. For the second spectrum a cylinder with 25mm ∅ was selected showing only the NAA signal of the inner phantom.

Short echo time *in vivo* MRS measurements were performed using a cylindrical excitation with 25mm ∅ (25mm thickness) located in the grey matter of the occipital cortex (Fig. 3A). The side excitations which are observed in the corresponding 2DRF spin-echo imaging sequence (Fig. 3B) do not contribute to the spectroscopy signal since they are suppressed by the second slice-selective refocusing pulse. 127 averages were acquired (TR=3s, TA=6.5min), the spectrum is shown in Fig. 3C. The data-fit with LCModel results in quantification of NAA, Ch, Glx, Cr and mI with Cramér-Rao lower bounds below 15%.

It should be emphasised that the signal-to-noise ratio is reduced compared to localisation based on orthogonal sections. This is in particular due to the lower flip angle and the fact that not all excited 2DRF segments are contributing to the overall signal.

However, for non-convex voxel shapes like the ring shown in Fig. 2b the better coverage obtainable with the 2DRF may more than compensate this signal loss. Furthermore other trajectories that involve repeated coverage of the central segment may further increase the signal.

References

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