Semi-LASER 1H-MR spectroscopic imaging of the human brain at 7T

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Introduction

Previously we have demonstrated that ^{1}H-MR spectroscopic imaging of a large VOI in the human brain at 3T with an echo-time of 30 ms and minimal chemical shift displacement is possible using a semi-LASER sequence [1]. This sequence also turned out to be useful for ^{1}H MRSI of human brain at 7T [2]. The adiabatic refocussing pulses in this sequence overcome inhomogeneities of the B_1 transmit field and their relatively high bandwidth provide an acceptable chemical shift displacement error. However, with the standard CP head coil and available RF power the lenghth of the pulses had to be at least 10 ms leading to a minimum echo time of 50 ms. In this study we used a sixteen-channel geometrically adjustable transmission line array headcoil [3] with high efficiency as a transceiver at 7T. The duration of the adiabatic pulses could be reduced to 5 ms, enabling an echo time of 30 ms. The sharp selection profiles of the radiofrequency (RF) pulses combined with apodization of k-space before Fourier Transformation kept lipid contamination to acceptable levels, even without outer volume saturation pulses.

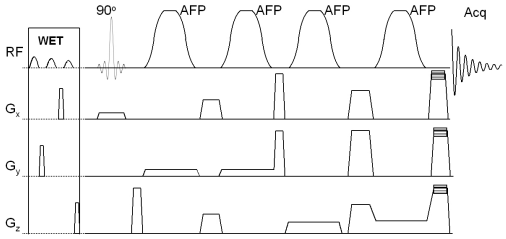

Figure 1. The semi-LASER spectroscopic imaging pulse sequence. The water suppression (WET) module is not drawn to scale.

Materials and methods

Set-up. A 46-year-old male volunteer was examined on a 90-cm-bore magnet operating at 7T (Magnex Scientific, Abingdon, UK), driven by a Siemens Syngo console (Siemens Medical Solutions, Erlangen, Germany). The sixteen-channel geometrically adjustable transmission line array coil used in this study has been described elsewhere [4] For RF excitation, we used a combination of eight 1kW RF amplifiers (CPC, Brentwood, NY, USA) and one 8 kW RF amplifier (Siemens Medical Solutions, Erlangen, Germany), of which the power was split with equal amplitude and fixed phase increments with an eight-way power splitter (Werlatone, Inc., Brewster, NY, USA). We used a static, general B_1-shimming scheme of phase increments for the different channels for an average-optimum transmit B_1. The digi-tal receiver system of the console handled signals from all coil elements separately.

2D ^{1}H-spectroscopic imaging of the brain. 3D volume localization was achieved by the combination of an initial slice-selective Shinnar-Le-Roux optimized 90º excitation pulse with two pairs of slice-selective adiabatic full passage (AFP) 180º refocusing pulses (fig. 1). The second order hyperbolic secant AFPs had a duration of 5 ms each, enabling an echo time of 30 ms. The RF efficiency of the coil and available RF peak power easily allowed a γB_1 field of 1150 Hz for these pulses. Water signals were suppressed with a WET pulse scheme, no outer volume saturation slabs were used. After filtering (100% Hamming filter), zerofilling to the nearest power of two and spatial Fourier transformation of the elliptically sampled k-space data the signals of the individual voxels were filtered and Fourier transformed into spectra. The RF power deposition of the semi-LASER sequence was kept at 44% of the global head SAR limit by choosing a repetition time of 4 sec. Other parameters for the MRSI measurement were: carrier frequency at 2.7 ppm, field of view 126 x 154 mm, matrix size 14 x 18, slice thickness 9 mm, volume of interest 70 x 100 mm and total acquisition time 9:42 min.

Results and discussion

With the high efficiency of the 16 channel transmission line coil the duration of the AFPs could be reduced, enabling ^{1}H-MRSI of a large VOI in the brain at 7T with a short echo time (30 ms). Residual heterogeneity in signal intensities across the brain (fig. 2) is the result of non-adiabatic excitation and non-uniform signal reception. This can be overcome by the acquisition of a separate water reference signal for corrections. Alternatively, ^{1}H MRSI can be performed with only partially suppressed water signal, so that this (residual) signal can then be used for normalization of all signals, or for absolute quantification with LCModel. 3D volume selection of the VOI was accurate enough so that lipid signals were not present within the current VOI. If the VOI is chosen closer to the skull, outer volume saturation slabs will be needed to suppress lipid signals, which will increase the RF power deposition of the sequence. Dynamic B_1 shimming can counteract this increase, it could also be of use to individually adjust these outer volume saturation pulses, and it could overcome B_1 transmit inhomogeneities of the excitation pulse.

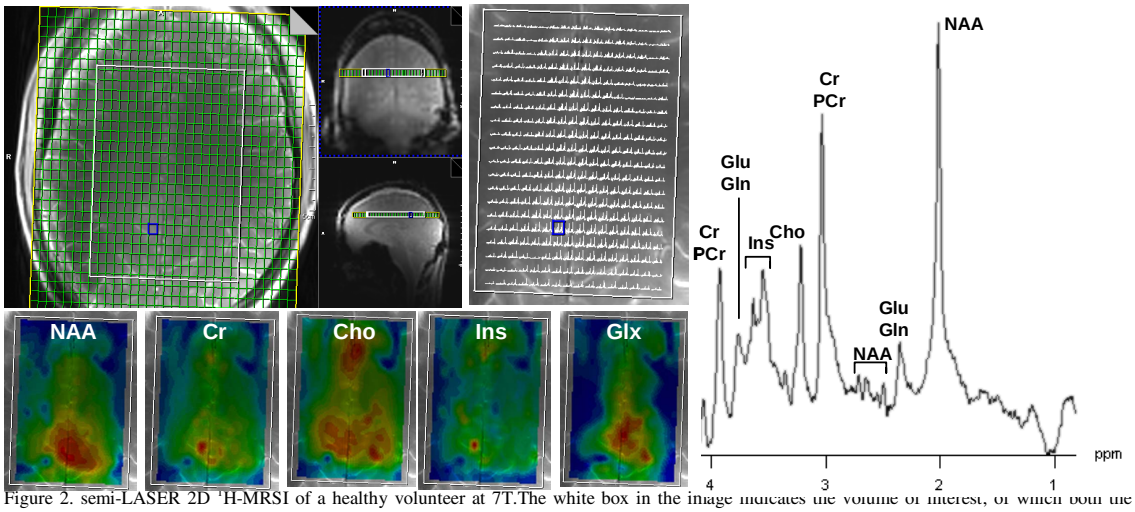

Figure 2. semi-LASER 2D ^{1}H-MRSI of a healthy volunteer at 7T.The white box in the image indicates the volume of interest, of which both the spectral map and metabolite maps, constructed with the Siemens Syngo software (automatic phasing, baseline correction and curve fitting), exhibit signal heterogeneity over the brain. In one of the spectra (location indicated with the blue square) metabolite resonances are assigned (right).

References:

1. Scheenen, Magn Reson Med. 2007 Oct 29. 2 Scheenen, MAGMA (in press). 3. Adriany, 13th proc ISMRM p. 673 (2005). 4. Adriany, Magn Reson Med. *in press*.

Acknowledgements

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