Short TE (15ms) Spectroscopic Imaging of the Human Brain at 7T Using Transceiver Arrays and B1 Shimming Based Localization

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Introduction: Despite the presence of ultra high field systems (7T) dating from late 1990s, there have been few reports of their use in spectroscopic imaging (SI) studies. This limitation is due to the inherent disadvantages of high field which result in a 5-12 fold increase in power deposition at 7T in comparison to 3T. These problems become especially severe when in–plane volume localization is used for SI. To overcome these limitations we have developed a short TE (15ms) SI sequence utilizing an 8 element 7T transceiver array and a B_1 shimming based method for in-plane localization. This method reduces the required peak power by 456% and does not require gradient selection, thereby eliminating spatial mis-registration errors. We have utilized this method to acquire high resolution (0.36cc) spectroscopic images of the human brain at 7T of glutamate, glutamine and macromolecules in controls with an average power deposition of 1W/kg.

Methods: All data were acquired with a Varian Direct Drive system and a head only (68cm ID) actively shielded 7T magnet. Two unique spatial distributions of B_1 were used in this sequence. Distribution RF#1 (Fig 1a,2) was a homogeneous distribution while the distribution RF#2 restricts the B_1 to a ring about the head (Fig 1b,2). These distributions were generated using B_1 maps and RF shimming to determine the 8 independent amplitudes and phases used for these distributions. SI data (TE/TR = 15/1500ms) were acquired using the sequence shown in Fig. 2. The homogeneous distribution was used for slice selection (red), water suppression and refocusing (green). The ring distribution was used with a double inversion recovery sequence (yellow, TIR_1/TIR_2 = 600/180ms) and adiabatic pulses, which provides >96% suppression for resonances with T1s between 0.4 and 2000ms.

Fig. 1a

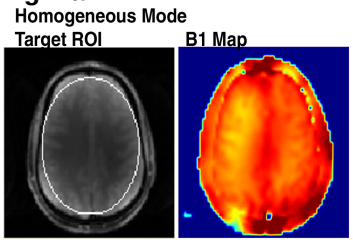


Fig. 1b

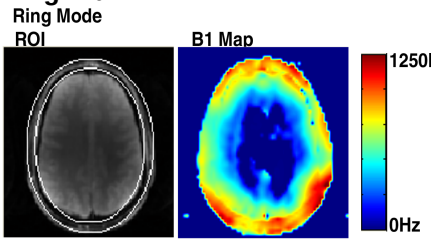
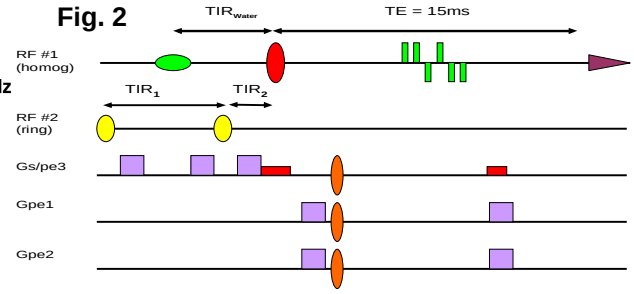
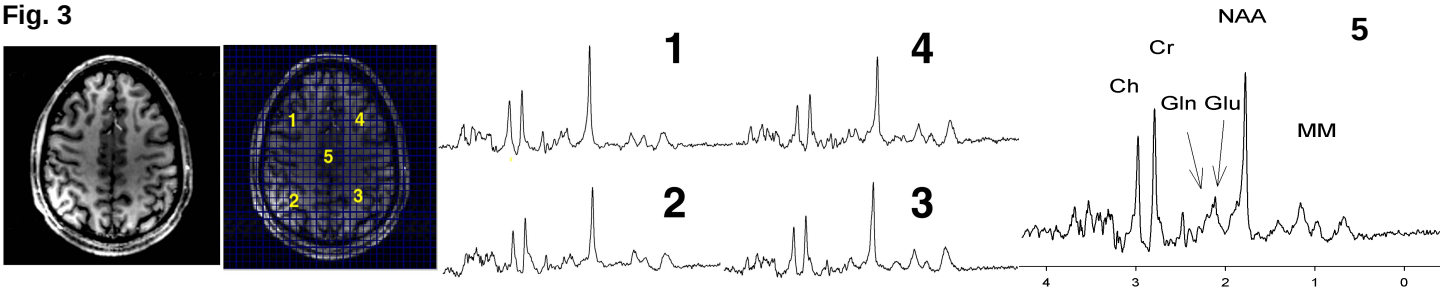


Fig. 2



Results: The homogenous and ring distributions achieved their target B_1 values (1kHz) using peak powers of 1934±349W and 424±53W respectively (n=5 volunteers). The efficiency of the sequence in suppressing unwanted regions (ROI in Fig. 1b) was assessed by comparing the residual signal (integrating the signal from 0.7-1.7ppm) from 8 locations distributed at 45˚ degree increments about the ROI. The sequence achieved a 98.4±0.5% reduction in signal intensity in comparison to data acquired without in-plane localization. In comparison, data acquired from the same individuals with a single non-spatially selective inversion pulse (TIR/TR = 350/3000ms) achieved 94.1±1.0% suppression but also reduced metabolite signals in the brain by 60%, despite a doubling of the TR. Displayed in Fig 3 are data acquired using 32x32 encodes (FOV=192x192mm) and a 10mm slice thickness from a control subject (TR=1500ms/25min).

Fig. 3



Conclusions: The double IR suppression method using the ring distribution achieves: 1) a 4.5-fold reduction in peak power deposition (424W) in comparison to the homogeneous mode (1.9kW); 2) achieves > 98% reduction in extracerebral signals, 3) retains all of the available SNR from central brain regions and 4) allows the TE to be minimized enabling J-modulating compounds (glutamate and glutamine) and short TE compounds (macromolecules) to be measured with high efficiency. Finally, the reduction in peak power allows TRs of 1.5S to be used with average depositions of ~1W/kg.