An Automated Shim Mapping Method for Spectroscopic Imaging of the Human Hippocampus

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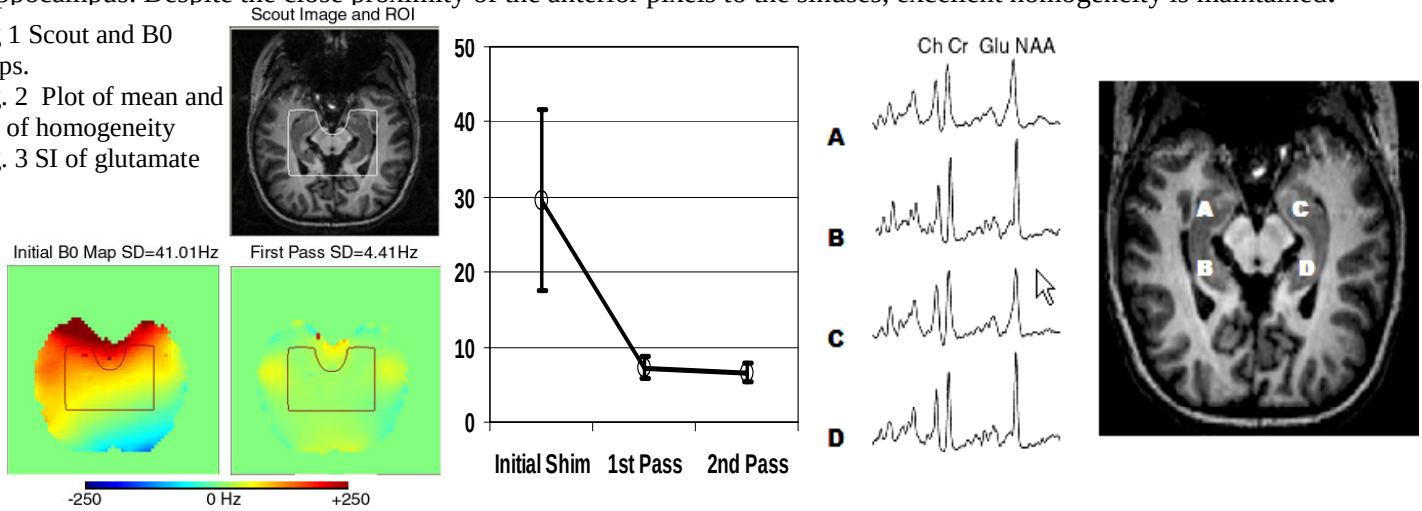
Introduction: Although a variety of methods have been proposed to provide automated adjustment of shim homogeneity, these methods typically fail or require large numbers of iterations *in vivo* when applied to regions with poor homogeneity such as the temporal lobe. These limitations are largely due to: 1) the limited accuracy of single evolution time measurements when using full B0 mapping studies and 2) inaccuracies arising from projection based methods when the projections pass through regions where the inhomogeneity exceeds the order of the fitted parameters. To overcome these limitations we have developed a novel B0 mapping methods using multiple evolution times with a novel unwrapping scheme in combination with a user defined ROI selection tool. We have used these methods at 4T in 10 sequential control subjects to obtain high-resolution spectroscopic images of glutamate from the bilateral hippocampi.

Methods: All data were acquired on a Varian INOVA 4T system using a quadrature head coil. B0 maps were obtained using a multi-slice (11 slices, 2mm thick/2mm gap) gradient echo imaging sequence (64x64 resolution, FOV 192x192mm) with 5 B0 evolution delays (0,1,2,4 and 8ms) with a 96s measurement time. The B0 map was calculated by using each evolution delay to correct for phase wrapping in the image with the next longest evolution time. This allows the measured B0 map to have the frequency span of the shortest evolution time (1ms, ±500Hz) and the accuracy of the longest evolution time 8ms (~0.3Hz/degree). To avoid the higher B0 gradients (up to 6th order) over the sinuses, data from an irregular ("guillotine") ROI (3 slices, ~1480 pixels, Figure 1) was selected and fit using 3rd order spherical harmonics constrained to the physical limitations of the shim power supplies. After shim correction, the process was repeated to assess the achieved homogeneity and a second correction (5 subjects) was calculated and applied when the SD of the B0 homogeneity was >1Hz of the predicted optimum. A spectroscopic image of glutamate was then acquired, (16x16 encodes, FOV=192x192mm, 10 mm thickness, ROI=80x100mm, 32min acquisition).

Results: Fig. 1 displays a scout image showing the triply obliqued plane and selected ROI, and B0 maps prior to shimming and after a single iteration. The residual B0 inhomogeneity largely reflects fourth and higher order asymmetries, not correctable with 3rd order shims. Displayed in Fig. 2 are the data acquired from 10 subjects plotting the standard deviation of the B0. The mean difference between the achieved homogeneity and the predicted best homogeneity was 1.22±0.62Hz after a single iteration and 0.67±0.37 Hz after two iterations. Displayed in Fig. 3 are spectra from the hippocampus. Despite the close proximity of the anterior pixels to the sinuses, excellent homogeneity is maintained.

Fig 1 Scout and B0 maps.
Fig. 2 Plot of mean and SD of homogeneity
Fig. 3 SI of glutamate



Conclusions: The described shim routine provides a highly robust and completely automated method to optimize the homogeneity of the human hippocampi. The use of the incremented evolution times provided a highly accurate B0 map minimizing the number of iterations required while providing a large initial bandwidth for relatively poor starting positions. The use of an irregular ROI, focuses the shim corrections to the hippocampi while avoiding regions with very high order B0 gradients. The method is also directly applicable to other brain regions such as the thalamus and basal ganglia and whole slices from superior locations by tailoring the ROI geometry to the target location.