Reproducibility of 1H Spectroscopic Imaging of the Human Hippocampus

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Introduction: ^{1}H spectroscopic imaging (SI) of NAA has proven to be a highly useful in the identification of neuronal injury in the hippocampus of patients with temporal lobe epilepsy and Alzheimer's disease. Despite the non-invasive nature of the measurement, few longitudinal SI studies of the hippocampus have been reported. This is largely due to the inherent difficulties in acquiring reproducible spectroscopic images of the hippocampus. These difficulties include 1) the strong regional effects of B_0 inhomogeneity, making shimming and water suppression difficult and 2) the effects of tissue heterogeneity, resulting in large variations in metabolite levels over relatively small distances. We have developed an automated co-registration, selection and reconstruction method that maximizes anatomical coherence between different SI studies. This has been applied with triply obliqued imaging of the hippocampal plane, a 3D localized SI sequence and high capacity shims (up to third order) to assess improvements in scan-to-scan variability.

Methods: Spectroscopic images were acquired with a 4T Varian INOVA system using a volume TEM head coil. Spectra were localized to a 10x80x100 voxel angulated along the temporal pole using three dimensions of adiabatic refocusing pulses. Water suppression was provided by a combination of CHESS and a broad-band semi-selective excitation pulse. The data was acquired using TE/TR of 72/2000ms, FOV 192x192mm^2 with 24x24 encodes (19min). Shimming (up to 3rd order) was provided by a high capacity 10A supplies. To provide for reproducible voxel selection and reconstruction, an automated co-registration, selection and reconstruction routine was used. The images were co-registered (translated and rotated) by maximizing the overlap (equivalent tissue assignment) between two tissue-segmented anatomical images. Five non-overlapping voxels from each hippocampus (10 per study) were automatically reconstructed by translating along the hippocampal midline with voxel #3 placed at the level of the aqueduct (Fig. 1). To evaluate the method, we acquired two ^{1}H hippocampal SI studies in 5 subjects, ranging from 7 to 146 days separation. The standard deviation (SD) of the difference in the CR/NAA ratio between identical voxels from the two studies was calculated along with a regression analysis. For comparison purposes, we also selected 5 similar voxels (voxel #3 also at the level of the aqueduct) using the SI determined grid following the contours of the hippocampi but without co-registration or voxel shifting (Fig. 2).

Results: Displayed in Figs 1 and 2 are the loci selected using the two methods described. Spectra from the 5 positions of the right hippocampus for two studies (acquired from an volunteer separated by 146 days) using the co-registration method are shown in Fig 3. Excellent spectral quality is obtained along the entire hippocampus. Due to the complex anatomy of the hippocampus, substantial variations in the tissue content occur, which results in large variations (a factor of 2.5) in metabolite ratios of individual voxels. Despite this, the spectra selected from the same loci in the same individual but from different studies are remarkably similar, supporting the accuracy of the method. The SDs of the differences in CR/NAA vary between 0.052 to 0.089 for the co-registered data, and 0.107 to 0.188 using the conventional method. A regression analysis (Fig. 4) correlating the individual voxels between the two studies yielded an R=0.84 for the co-registered data in comparison to R=0.46 for the conventional voxel selection method.

Figure 1

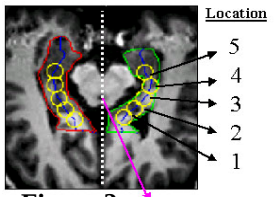


Figure 2

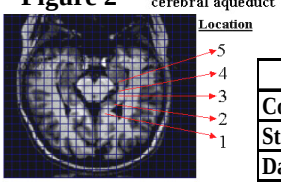


Figure 3

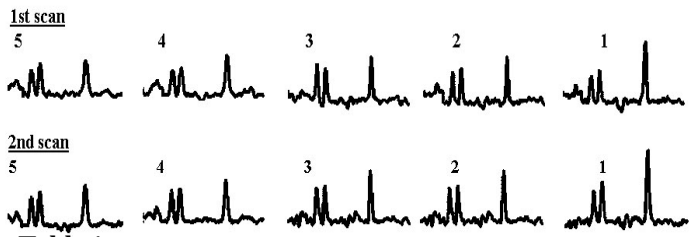
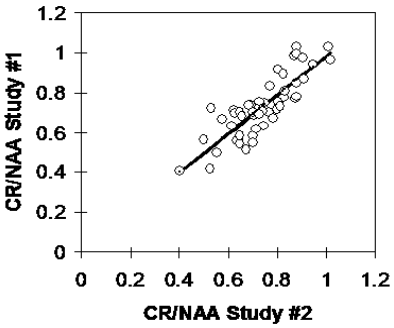


Table 1

		1	2	3	4	5	Avg.
Coregistered	SD	0.089	0.052	0.068	0.075	0.080	0.073
Standard	SD	0.123	0.108	0.166	0.188	0.107	0.138
Days Between Studies		7	146	8	13	19	

Figure 4



Discussion: Compared to conventional voxel selection routines, these methods reduce the scan-to-scan variability of Cr/NAA throughout the hippocampus by 47%. The smaller control SD of 0.07 is ~20% of mean difference between controls and patients with temporal lobe epilepsy or Alzheimers (ΔCR/NAA=0.35). This approach should allow longitudinal studies in these patient groups, comparing changes at the level of single voxels (0.64cc).