High-resolution Quantitative T1 Maps of the Human Stria of Gennari at 7 Tesla

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Introduction: High-resolution T1-weighted MR images show intra-cortical contrast that reflects cortical myeloarchitecture. The easiest intra-cortical structure to identify is the stria of Gennari, the densely myelinated layer IVb within the primary visual cortex V1. It is approximately 280 µm thick [1] and can be seen in postmortem tissue with the naked eye. It has also been shown in several high-resolution in-vivo MRI studies [e.g. 2,3]. These are the first reported quantitative estimates of T1 in the stria of Gennari in-vivo at any field strength.

Methods: 2 human subjects were scanned on a 7 Tesla (T) MR system with a 24-channel receive-only head coil. MP2RAGE sequences (TI1/TI2 = 900/2750 ms, TR = 5 s, TE = 2.45 ms, $alpha_1/alpha_2$ = 5°/3°, bandwidth = 250 Hz/Px, echo spaging = 6.8ms, partial Fourier = 6/8) were used to obtain quantitative T1 images of the whole brain at 0.7 mm isotropic resolution, and of the left and right hemispheres at 0.5 mm isotropic resolution. The three images were co-registered into MNI space at an isotropic resolution of 0.4 mm, and fused to generate a whole brain T1 map. The T1 maps were segmented and the cortical surfaces were reconstructed [4]. Cortical profiles were obtained with a volume-preserving layering model, sampling 21 cortical contours within the cortical boundaries [5]. We manually labeled V1, as well as the stria of Gennari within a small ROI of V1. The entire stria was sampled at a constant cortical depth using a mask defined by our novel cortical layering model, which follows the laminae in areas of curvature.

Results: A coronal view of the T1 times in the calcarine sulcus of subject 1 is shown in Fig.1. The manual labels of the stria of Gennari corresponded to cortical depths of 43±8 and 47±8% from the pial surface for subjects 1 and 2 respectively. The automated stria mask for subject 1 is overlaid in red on the greyscale T1 map in Fig. 2. Fig. 3 displays the mean cortical profile of T1 in V1 for each subject, as well as typical individual profiles. Layer IVb is labeled by a vertical yellow band according to our depth measurements, and a blue band at 54±7% according to histological measurements by von Economo & Koskinas [1]. These labels overlap (in green) and are well aligned with the local T1 minima of the profiles. Values of T1 at different cortical depths are shown in Table 1. Note that the supragranular layers have a characteristically longer T1 than the infragranular layers, reflecting the lower myelination nearer the cortical surface easily observable in histological sections stained for myelin. The first and last 10% of the cortex were excluded to minimize partial volume effects with white matter and cerebrospinal fluid.

Fig. 1: Coronal view of the calcarine sulcus in the 0.5 mm T1 map (ms) of subject 1 at 7 T.

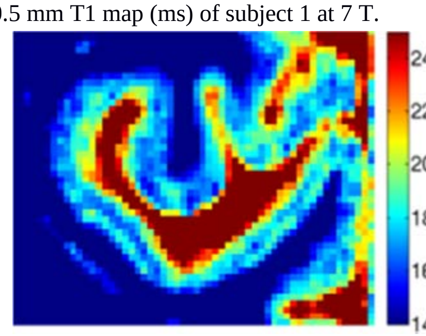
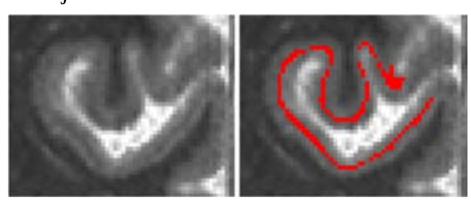


Fig. 2: Automated masking of the stria of Gennari in subject 1.



Discussion: This is the first report of high resolution T1 maps, a quantitative index of myelination, at high enough resolution to clearly depict the stria of Gennari in V1. Our voxel size is larger than the width of the stria of Gennari, yet the stria is clearly visible in the MR images due to its high contrast with neighboring cortical layers. We used an equi-volume layering approach, which defines realistic cortical contours following the laminae in areas of curvature. Small grey/white segmentation errors cause slight misalignments of the cortical profiles, resulting in a smoother mean profile, lacking the local minima in layer IVb observable in the individual profiles. Due to these boundary inaccuracies and partial volume effects, the tabulated mean values of T1 within the stria of Gennari are longer than those found in many of the individual profiles.

Fig. 3: Cortical profile of T1 times in V1 at 7 T for subj. 1 (left) and subj. 2 (right).

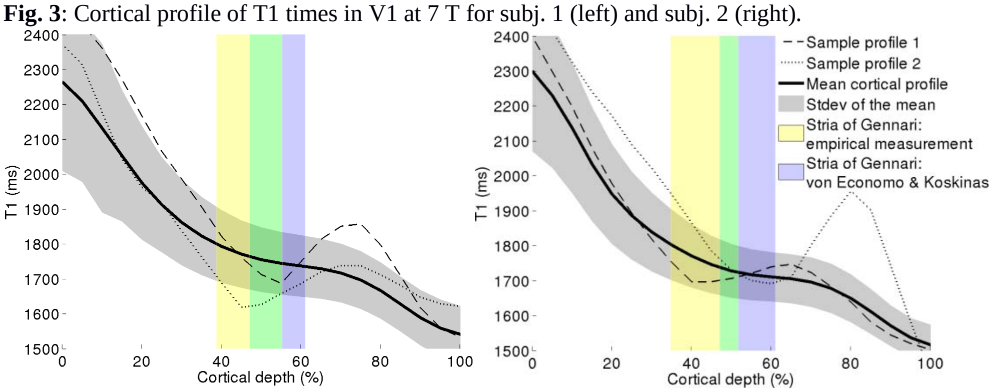


Table 1: Mean values of T1 (stdev) of V1 at 7 T, in ms.

Cortical layers	Subject 1	Subject 2
I - IVa	1919 (191)	1908 (181)
IVb	**1757 (108)**	**1745 (101)**
IVc - VI	1701 (112)	1677 (95)
All layers	1796 (177)	1762 (163)

References: [1] von Economo & Koskinas 1925 [2] Trampel et al. Cereb Cortex 2011 [3] Sanchez-Panchuelo et al. JMRI 2011 [4] Bazin et al. OHBM 2012 #883 [5] Waehnert et al. OHBM 2012 #898