

Enhanced T1-weighted myelin contrast in gray matter at 7T

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Introduction The ability to visualize the detailed cortical myeloarchitecture has clear implications for the study of neurological diseases such as multiple sclerosis, but also opens a new avenue to morphologically differentiate between functionally distinct cortical regions in vivo. In conjunction with functional imaging, this can allow a direct detailed correlation of function and structure in individuals [1]. Recent studies at high field have shown excellent in vivo visualization of myelin content within gray matter based on T1 contrast [1-4] that is approaching a detail that is currently attainable only with post-mortem histology. In non-human primates, it was shown that optimizing the T1-weighting between high and low myelin content gray matter can further reveal subtle features of myeloarchitecture [2]. Here we employ such an approach in humans to obtain very high resolution myelin sensitive T1w images.

Methods Scanning (n=4) was performed at 7T (Philips) using a volume transmit and 32-channel receive head coil (Nova Medical). A 3D MPRAGE sequence was modified to obtain a strong T1 contrast in high myelin content gray matter while suppressing signals from low (or no) myelin content gray matter: the time delay (TD) between inversion pulses was optimized such that the difference in longitudinal magnetization prior to the inversion pulse was increased between white and gray matter, and the inversion delay (TI) was optimized such that the gray matter signal was just above the null point. An optimum contrast was obtained at TD = 6s and TI = 1200ms, confirmed by visual inspection of images acquired at several TI and TD combinations. At the TI and TD chosen, CSF is below the null point and appears bright in magnitude images. Therefore real images were also reconstructed, in which CSF is dark, and were used to mask CSF in the magnitude images by intensity thresholding. Other parameters were: TR/TE: 8/3ms, flip-angle: 8°, BW: 202Hz/px, turbo factor: 275, single-shot, and adiabatic inversion. A 3D volume was acquired over the visual cortex with a 0.5 mm isotropic resolution (FOV: 140x140x30 mm). Two or three scans were acquired per subject and were averaged after rigid-body co-registration using AFNI followed by skull-stripping.

Results Figure 1 B-D illustrate the strong T1 contrast obtained with the modified MPRAGE sequence between low myelin content and high myelin content gray matter, and white matter, for one subject. The stria of Gennari, characterized by myelinated axons in layer V of the striate visual cortex, is distinctly visible within and around the calcarine sulcus (white arrows, Fig. B, C). Also visible are regional variations in T1 contrast in extrastriate cortex with a pattern orthogonal to the cortical surface. This is particularly evident in the zoomed view (Fig. 1D, yellow arrows) and may reflect local variations in myelin content as predicted by histology [5]. Figure 1 A shows an example of the acquired magnitude images before processing. Similar results were obtained for all subjects.

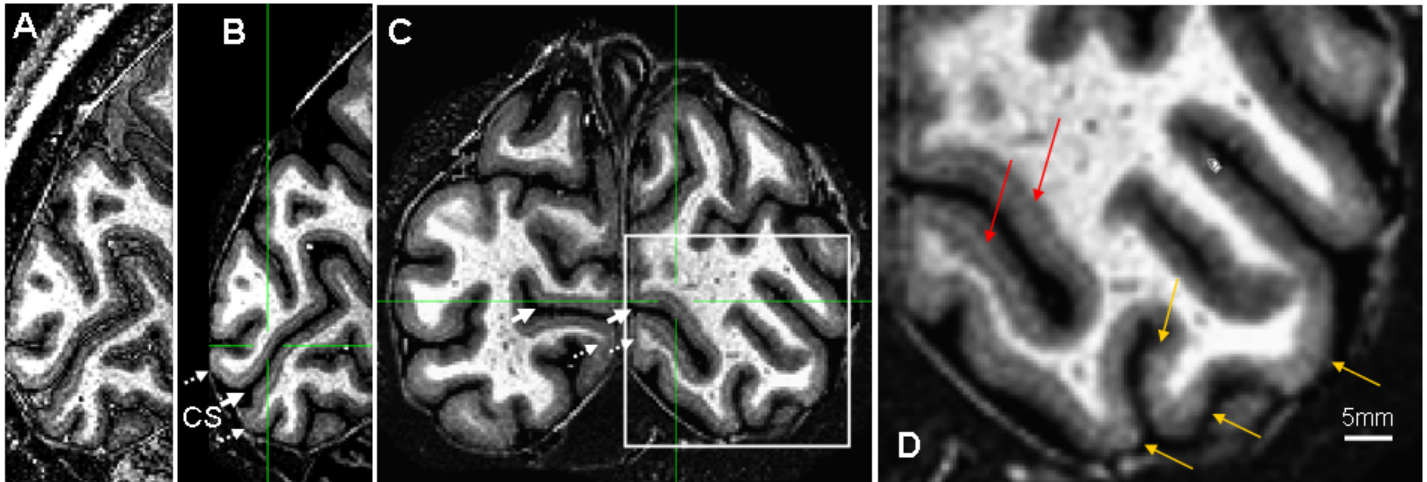


Figure 1. A T1w magnitude image obtained with the modified MPRAGE, with bright CSF and dark gray matter. B-D: images after masking CSF, skull-stripping, and averaging two scans. Sagittal (B) and Coronal (C) views of the visual cortex, showing a strong T1 contrast between gray and white matter, and regional variations in T1 contrast within gray matter, including the line of Gennari. CS: calcarine sulcus, marked by white arrows in B,C). Crosshairs in B, C mark the location of the coronal and sagittal slices shown. Panel D shows a zoomed view of the boxed region in C. Red arrows point to the line of Gennari. Yellow arrows point to marked variations in gray matter T1 contrast in extrastriate visual cortex.

Discussion Our results show excellent visualization of presumably mainly myelin content within gray matter, as observed for the stria of Gennari, as well as excellent contrast between white and gray matter. Furthermore, the strong T1 weighting combined with the very high spatial resolution, revealed spatially detailed T1 contrast variations in early extra-striate visual cortex, which may correspond to local differences in myelin content reflecting inputs from different visual pathways as suggested by histology [5]. This enhanced myelin sensitivity can bridge between in vivo functional and histological mapping of cortical micro-architecture in humans.

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