Comparison of retinotopic maps with cortical areas identified using high resolution, T2*-weighted images acquired at 7T

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Introduction

One of the major aims of neuroscience is a detailed understanding of the relationship between structure, detailed anatomy and function of different regions in the human brain. Previous studies have defined visual cortical regions V1 (1,2) and MT (2) anatomically *in vivo* using high resolution T_1-weighted images. Here we study the correspondence of these functionally defined regions to their underlying structural anatomy using high resolution T_2^*-weighted imaging at 7 T.

Methods

Scanning was performed on a 7 T Philips Achieva System using a 16 channel SENSE coil. Each of the subjects participated in two scanning sessions. In the first scanning session we performed retinotopic mapping using a stimulus that rotated slowly through the visual field about a central fixation point. A GE-EPI protocol with a TR of 3s and a TE of 25ms allowed 30 axial slices (oriented parallel to the calcarine sulcus) to be acquired with 1.5mm isotropic resolution (144 x 96 mm^2 FOV). Each functional scan (24s cycle, 10 repeats; total time 240s) was repeated twice. The retinotopy stimulus was a circular aperture filled with black dots on a white backgound. The dots within the moving 90^o wedge alternated between an expanding and contracting motion, while the rest of the dots remained stationary. This motion-defined wedge rotated 45^o every 3s, completing a full rotation every 24s. The stimulus was projected onto a screen at the end of the scanner bed and viewed by the subject using prism goggles. The scanner bore restricted the extent of the stimulus to approximately 9^o of visual angle This paradigm allows the identification of early retintopic areas (V1, V2, V3) , as well as the motion-selective visual area MT.

In the second scanning session high resolution T_2^* - weighted structural images were acquired. A 3D spoiled, gradient echo sequence with a TR of 50ms, a TE of 20ms and a flip angle of 16^o was used to obtain 84 coronal slices at 0.4 mm isotropic resolution aligned perpendicular to the calcarine sulcus and spanning a 192 x 192 x 33.6 mm^3 volume. We aquired 2 sets of individual scans consisting of 2 averages which were then co-registered and averaged together (23'16'' total scanning time) . T_1-weighted MPRAGE image data sets, with the same slice prescription as both the EPI and high resolution, T_2^*-weighted data, were also acquired at the end of both scanning sessions to allow registration to a previously acquired reference volume. The fMRI data were analyzed using standard methods for retinotopic mapping (4). At each voxel the Fourier-transform of the time series gives the coherence and the phase of the best fitting sinusoid at the stimulus repetition frequency. The phase of the periodic fMRI response at each voxel gives information about the angular position of the stimulus in the visual field. In order to identify V1 and MT the functional data were transformed onto a flattened representation of the cortex using custom software (5). The boundaries of V1 and MT were identified from the phase reversals of the inflated retinotopic map. The areas of the T_2^*-weighted images which clearly exhibited a dark band within the cortical gray matter were identified manually. As with the functional data, the manually labelled regions of banding were transformed into inflated cortical space.

Results and Discussion

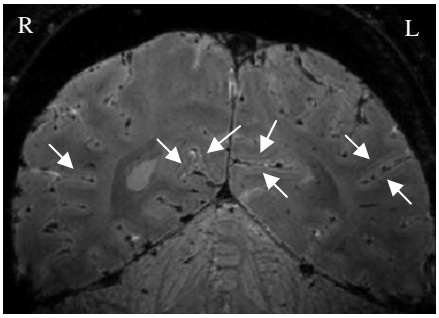

Figure 1: High resolution image (0.4 mm isotropic) showing a hypointense band within the grey matter (marked by the arrows).

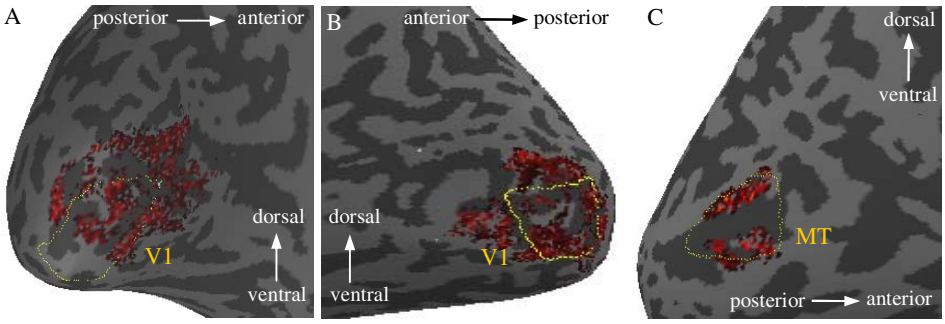

Figure 2: Structural and functional maps of the striate cortex. Red, manual labels of structural, hypointense bands. Yellow lines, outline of functionally defined areas V1 and MT. (A) left (B,C) right hemisphere.

A hypointense band, conforming to the expected anatomical location of the stria of Gennari, was evident within the cortical grey matter in the visual cortex of all subjects scanned. Figure 1 shows example T_2^*-weighted data acquired from one subject. A hypointense band (white arrows) is clearly visible within the cortical grey matter at the calcarine sulcus, as well as in more lateral regions of the occipital lobe. Figure 2 shows the extent of V1/striate cortex (A-B) and MT (C) determined from the retinotopic maps transformed onto inflated representations of the cortex for the same subject. Light areas represent the gyri and dark areas the sulci. The red region, which overlaps the V1 area defined via retinotopic mapping, represents the areas in which the hypointense band was identified in the T_2^*-weighted data. This region extends further than the functionally defined area V1 in the anterior direction. This discrepancy could be explained in part because the paradigm did not activate the whole of V1 as a result of the limited extent of the visual field spanned by the stimulus. The FOV used for the T_2^*-weighted imaging also did not cover the most posterior part of the occipital lobe in the left hemisphere, which may explain the smaller extent of the structurally defined striate region in the left hemisphere (A). A hypointense band was also evident in a portion of the functionally identified MT region (Fig. 2C). The high curvature of the cortex in the depth of the sulcus makes it difficult to identify the band in the region lying between the two red patches.

Conclusion

We have shown that high resolution T_2^*-weighted images acquired at 7 T can be used to identify banding within cortical grey matter in reasonable measurement times. A hypointense band of signal intensity in the grey matter of the occipital lobe was seen in all four subjects scanned. Regions where this band was identified overlapped with the functionally defined V1 area. Evidence of banding was also found in the functionally defined MT area..

References

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