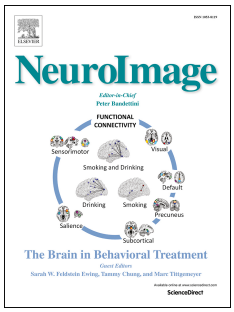
Accepted Manuscript



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PII: S1053-8119(18)30162-9

DOI: 10.1016/j.neuroimage.2018.02.055

Reference: YNIMG 14756

To appear in: *NeuroImage*

Received Date: 9 October 2017

Revised Date: 13 February 2018

Accepted Date: 26 February 2018

Please cite this article as: Edwards, L.J., Kirilina, E., Mohammadi, S., Weiskopf, N., Microstructural imaging of human neocortex in vivo, *NeuroImage* (2018), doi: 10.1016/j.neuroimage.2018.02.055.

Microstructural imaging of human neocortex in vivo

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Abstract

The neocortex of the human brain is the seat of higher brain function. Modern imaging techniques, chief among them magnetic resonance imaging (MRI), allow non-invasive imaging of this important structure.

Knowledge of the microstructure of the neocortex has classically come from post-mortem histological studies of human tissue, and extrapolations from invasive animal studies. From these studies, we know that the scale of important neocortical structure spans six orders of magnitude, ranging from the size of axonal diameters (microns), to the size of cortical areas responsible for integrating sensory information (centimetres). MRI presents an opportunity to move beyond classical methods, because MRI is non-invasive and MRI contrast is sensitive to neocortical microstructure over all these length scales. MRI thus allows inferences to be made about neocortical microstructure in vivo, i.e. MRI-based in vivo histology.

We review recent literature that has applied and developed MRI-based in vivo histology to probe the microstructure of the human neocortex, focusing specifically on myelin, iron, and neuronal fibre mapping. We find that applications such as cortical parcellation (using R_1 maps as proxies for myelin content) and investigation of cortical iron deposition with age (using $R_2{}^*$ maps) are already contributing to the frontiers of knowledge in neuroscience. Neuronal fibre mapping in the cortex remains challenging in vivo, but recent improvements in diffusion MRI hold promise for exciting applications in the near future. The literature also suggests that utilising multiple complementary quantitative MRI maps could increase the specificity of inferences about neocortical microstructure relative to contemporary techniques, but that further investment in modelling is required to appropriately combine the maps.

In vivo histology of human neocortical microstructure is undergoing rapid development. Future developments will improve its specificity, sensitivity, and clinical applicability, granting an ever greater ability to investigate neuroscientific and clinical questions about the human neocortex.

Keywords: hMRI, quantitative, high resolution

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