T1 Mapping to Identify Changes in Cortical Structure

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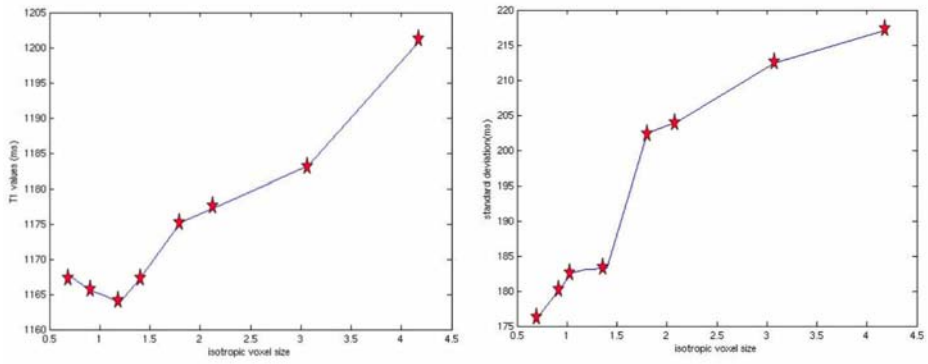
Introduction: Rapid T1 mapping is a potential clinical tool to identify and quantify the regional changes and abnormalities in cortical gray matter tissue. Sensitive to myelination in the cortex, T1 values may be used to determine the change of myelin content due to processes such as growth, ageing, disease and recovery.

One key problem with using T1 mapping in this way is the bias due to partial volume effects between the (highly folded and relatively thin) cortical gray matter and the neighboring tissues (white matter or cerebrospinal fluid), when the voxel sizes are large. The aim of this study was to determine the relationship between image resolution and the ability to detect bias-free cortical gray matter T1 values.

Methods: A high-resolution T1 map, acquired in vivo with DESPOT in 13 hours at 0.7x0.7x0.7 mm^3 resolution (Deoni, Josseau et al. 2005) using a GE (General Electric Medical Systems) 1.5T clinical scanner with a quadrature birdcage head-coil was used as a 'gold standard' data set. This data set comprised 60 axial slices centered around the ventricles. It was skull-stripped and segmented into three tissue classes automatically using FSL (FMRIB's Software Library). The gray matter mask was thresholded using the partial volume maps (computed automatically by FSL). Both the T1 map and the gray matter maps were down-sampled to simulate a data set acquired with lower resolution, using FLIRT (Jenkinson, Bannister et al. 2002). The mean and standard deviation of T1 values within all the gray matter were calculated.

Results: Both the mean and the standard deviation of the gray matter T1 values increase with decreasing resolution (see Fig. 1). This illustrates that the partial volume effects due to signal averaging with CSF become very prominent as the resolution goes down.



Down-sampling the high-resolution data set has shown that if T1 maps with resolutions worse than 1.5 mm are used, the ability to discriminate the differences in cortical T1 values diminishes significantly.

Discussion and Conclusion: The cortical T1 inhomogeneities observed in low-resolution T1 maps may be due to partial volume artifacts. T1 maps need to have a resolution of at least 1.5 mm (in all directions) in order to display changes across the cortex as function of cortical tissue structure. While it is challenging to get high enough SNR T1 maps at high resolution in a short enough scan time, in vivo discrimination of cortical tissue would be extremely useful as the structural variations may hold the key to how these regions function, and also what capacity they have for adaptation or reorganization after damage.

Deoni, S. C., M. J. Josseau, et al. (2005). "Visualization of thalamic nuclei on high resolution, multi-averaged T1 and T2 maps acquired at 1.5 T." Hum Brain Mapp 25(3): 353-9.

Jenkinson, M., P. Bannister, et al. (2002). "Improved optimization for the robust and accurate linear registration and motion correction of brain images." Neuroimage 17(2): 825-41.