# Comparing different contrasts for myelin-related cortical mapping at 7T

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**TARGET AUDIENCE:** Neuroscientists and clinicians interested in cortical mapping using (high-field) MRI.

**INTRODUCTION:** Several papers showed that differences in cortical myelin content measured by tissue staining is comparable with the changes in intensity observed in $T_1$(-weighted) and $T_{2(*)}$(-weighted) images[1,2]. Areas with high myelin content are hyperintense compared to areas with low myelin content in the $T_1$w and quantitative $R_1$ images. In $T_2$w images and quantitative $T_2$ and $T_2$*, myelin content decreases signal intensity. This myelin-related contrast can be enhanced and the bias field removed by calculating the $T_1$w/$T_2$w ratio[3]. However, as $T_1$w and $T_2$w images are non-linear functions of $T_1$- and $T_{2*}$-values, this ratio might misrepresent presumed myelin content. Therefore, the aim of this study is to determine commonalities and differences for all previously proposed weighted and quantitative contrasts in order to get further insights into the biophysical basis of myelin imaging with MRI.

**METHODS:** *Subjects and MRI:* Four healthy volunteers (aged 25-35, 2 females) participated in this study. MP2RAGE and multi-echo GRE data were acquired using a whole-body 7T magnet (Siemens Medical Systems, Erlangen, Germany) using 32-channel phased-array coil (Nova Medical, Wilmington, USA). Both datasets were acquired with a 0.7 mm isotropic resolution using the following parameters (MP2RAGE: TE 2.47 ms, TI1 900 ms, TI2 2750 ms, TR 5000 ms, GRAPPA 3 and GRE: TR 33 ms, TE1 2.53 ms, TE2 7.03 ms, TE3 12.55 ms, TE4 20.35 ms, GRAPPA 2). *Analysis:* First, MP2RAGE and GRE datasets were aligned with each other using SPM8 (Welcome Department of Imaging Neuroscience, University College London, London, UK). Next, $T_2$* was obtained from the GRE data using a monoexponential fit, whereas the GRE image acquired at TE4 was divided by the image acquired at TE1 to obtain a $T_{2*}$-weighted image corrected for receive bias fields. $T_1$w/$T_2$w and $R_1/T_{2*}$ ratio images were computed using the mitools software package. Subsequent anatomical analysis was performed using MIPAV 7.1.1 (Center for Information Technology, NIH, Bethesda, USA) and CBS tools 3.0.2 (Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany). The standard high-res analysis pipeline provided with the CBS tools package was used[4]. Minor changes were applied to the parameters to enhance the performance of the difference modules. The different contrasts (Figure 1A) were mapped to the mid-thickness surface of the individual inflated brains.

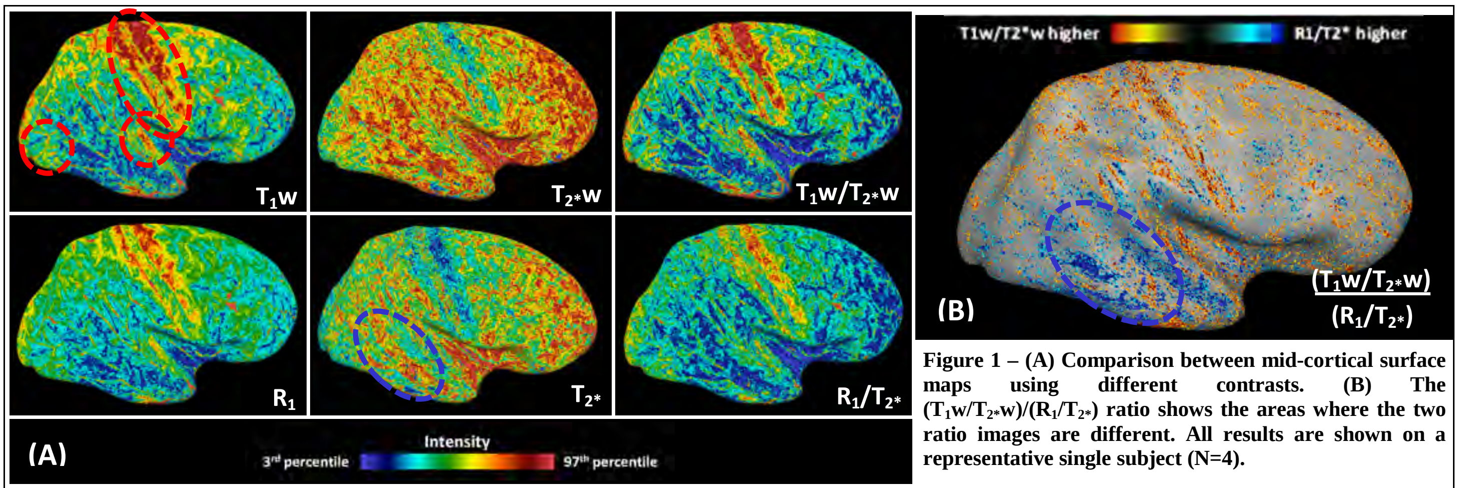


**Figure 1 – (A) Comparison between mid-cortical surface maps using different contrasts. (B) The ($T_1$w/$T_{2*}$w)/($R_1/T_{2*}$) ratio shows the areas where the two ratio images are different. All results are shown on a representative single subject (N=4).**

**RESULTS:** Similar intensity patterns, though with minor differences, are observed between the different contrasts (Figure 1). In all contrasts, the 'classical' highly myelinated areas, including the sensorimotor cortex, auditory cortex (highlighted with red in Figure 1A) and visual cortex, show increased contrast compared to other areas. Minor differences are observed between the weighted and quantitative images for $T_1$ and $T_2$* with regards to the size of these areas. Slightly larger areas are detected in the $T_1$w images compared to the quantitative $R_1$ ($1/T_1$) images. The opposite is true for the $T_2$* contrasts. Moreover, the intensity distribution shows a more patchy pattern in the quantitative $T_2$* images compared with the $T_2$*w images. Besides, the temporal lobe shows differences in intensity between the $T_2$*w and the $T_2$* images (highlighted with blue in Figure 1A/B). Both the patchy distribution and difference in temporal lobe intensity disappear in the quantitative $R_1/T_2$* ratio. Results were consistent between all four subjects.

**DISCUSSION:** The present results show that comparable 'myelination' patterns are detectable across all the investigated contrasts at 7T, though minor differences exist. Most of these differences seems to be induced by $T_2$* effects. We are currently investigating whether these differences might be partially explained by orientation dependency of $T_{2*}$, in particular in the temporal lobe [4]. Susceptibility artifacts in the inferior temporal and frontal lobe, which are exacerbated at 7T, may also affect the intensity pattern. Nevertheless, quantitative measurements are more directly related to physical or physiological tissue properties than weighted measurements and the differences between the two cannot be attributed solely to artifacts. More detailed (quantitative) analysis, that take potential confounds like cortical thickness and curvature into account, is important to compensate for possible differences induced by these anatomical factors.

**REFERENCES:** [1] Bock NA, Hashim E, Janik R et al. *Neuroimage*. 2012; [2] Stüber C, Morawski M, Schäfer A et al. *Neuroimage*. 2014 [3] Glasser MF & Van Essen DC. *Journal of Neuroscience*. 2011; [4] Bazin PL, Weiss M, Dinse J et al. *Neuroimage*. 2014 [5] Cohen-Adad J, Polimeni JR, Helmer KG et al. *Neuroimage*. 2012