

## MARTINI and GRAPPA - When Speed is Taste

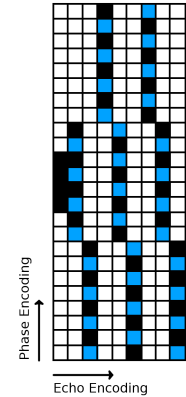
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**Target Audience:** Clinicians/researchers interested in highly accelerated imaging

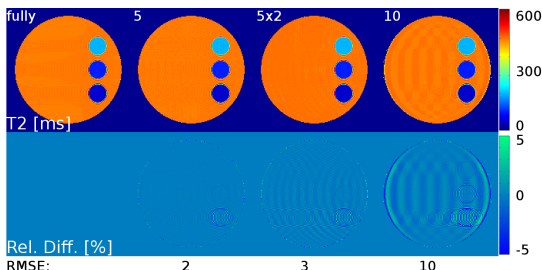
**Purpose:** Various advanced reconstruction techniques have been shown to allow reconstruction of subsampled data in order to accelerate image acquisitions. It is yet unknown, however, if these reconstruction methods are sufficiently orthogonal to be combined, which would enable even higher acceleration and/or improved image quality. Here, we investigate a combination of Model-based Accelerated Relaxometry by Iterative Nonlinear Inversion (MARTINI)<sup>1</sup> with Generalized Autocalibrating Partially Parallel Acquisition (GRAPPA)<sup>2</sup> and demonstrate initial experiences with its application to quantitative T2 mapping.

**Material & Methods:** Fully sampled whole-brain datasets of three healthy volunteers were acquired at 3T (MAGNETOM Trio and MAGNETOM Skyra, Siemens AG, Healthcare Sector, Erlangen, Germany) using a 32-element head coil and a multi-echo spin-echo sequence (TR/ΔTE=6520/9ms, 17 echoes, 1.1x1.1x4mm<sup>3</sup> resolution, 160x192 matrix size, 30 slices). Following Sumpf et al.<sup>4</sup>, data were synthetically 5-fold subsampled and reconstructed using the proposed MARTINI block scheme (fully sampled blocks of 32 lines whose k-space positions are shifted between echoes). To explore even higher acceleration factors, the method was extended by a two-fold subsampling of each sampling block (cf. black samples in Fig. 1). The GRAPPA kernels were trained on the first echo, where 16 continuous central k-space lines were sampled. Subsequently, the missing lines inside the sampling blocks were interpolated using the GRAPPA kernels prior to the standard MARTINI reconstruction. For validation, an 8-channel analytical phantom was generated using a sinusoidal complex coil-sensitivity model<sup>3</sup>. The resulting phantom and in-vivo T2 maps were compared to MARTINI-only reconstructions by calculating the RMSE and by visual inspection of the relative difference using the fully sampled reconstruction as reference.



**Figure 1** Schematic diagram of the accelerated sampling pattern (ex. 3x2 fold acceleration).

(■ sampled, ■ interpolated, □ zero-filled)



**Figure 2** T2 maps of the analytical phantom (top) and relative differences to the fully sampled reconstruction (bottom) using the proposed method (5x2) and MARTINI-only reconstructions (5 and 10).

**Results:** At 5- and 10-fold accelerations, increasing aliasing artifacts can be observed along the phase-encoding direction with MARTINI. Such artifacts originate from areas where the signal model is violated (due to CSF, flow, partial volume etc.). These aliasing artifacts can be observed in the 5- and 10-fold MARTINI images in the phantom (Fig. 2) and as well as in-vivo (Fig. 3) data. However, when combining the two-fold subsampling of the blocks and the 5-fold MARTINI reconstruction, only a subtle increase of artifact energy is observed that largely spreads over the entire image. Qualitatively, the 5x2-fold accelerated images largely resemble the 5-fold MARTINI reconstructions (Fig. 2 and Fig. 3). This is supported by comparing the RMSE, demonstrating that by increasing the acceleration factor from 5-fold to 5x2-fold the RMSE increases only from 50 to 51 (2 to 3 for phantom), while the 10-fold MARTINI brain images exhibit an RMSE of 67 (RMSE=10 in phantom).

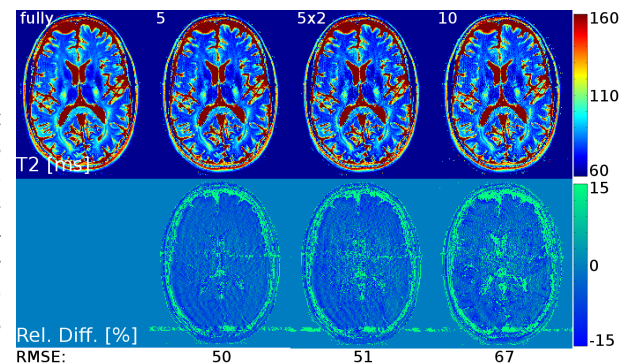
### Discussion & Conclusion:

This work demonstrates that a combination of MARTINI and GRAPPA is feasible and appears more robust to violations of the signal model with reduced aliasing artifact energy compared to the corresponding MARTINI-only reconstruction (i.e. 5x2 versus 10-fold acceleration). It should be noted that the GRAPPA interpolation introduces subtle model violations resulting in spatially distributed low-amplitude artifacts. In-vivo data exhibits several sources of model violations caused by flow, partial-volume, head-motion and noise (among others) whose artifactual signal energy show in a MARTINI-only reconstruction according to the actual sampling PSF. The added GRAPPA interpolation changes the effective PSF of MARTINI and thus reduces the introduced artifacts. In summary, the combination of GRAPPA and MARTINI shows promise to provide clinically usable data with very high acceleration factors, exemplarily shown here for 10-fold accelerated whole-brain T2 mapping which can be acquired in 1:40 min.

**References:** [1] Sumpf, Tilman J., et al. *JMRI* 34.2 (2011): 420-8.

[2] Griswold, Mark A., et al. *MRM* 47.6 (2002): 1202-10. [3] Guerquin-Kern, Matthieu, et al. *IEEE TMI* 31.3 (2012): 626-36.

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**Figure 3** In-vivo T2 maps (top) and relative differences to the fully sampled reconstruction (bottom) using the proposed method (5x2) and MARTINI-only reconstructions (5 and 10).