

**Supporting Material for:
LORAKS Makes Better SENSE:
Phase-Constrained Partial Fourier SENSE
Reconstruction without Phase Calibration**

Tae Hyung Kim, Kawin Setsompop, Justin P. Haldar

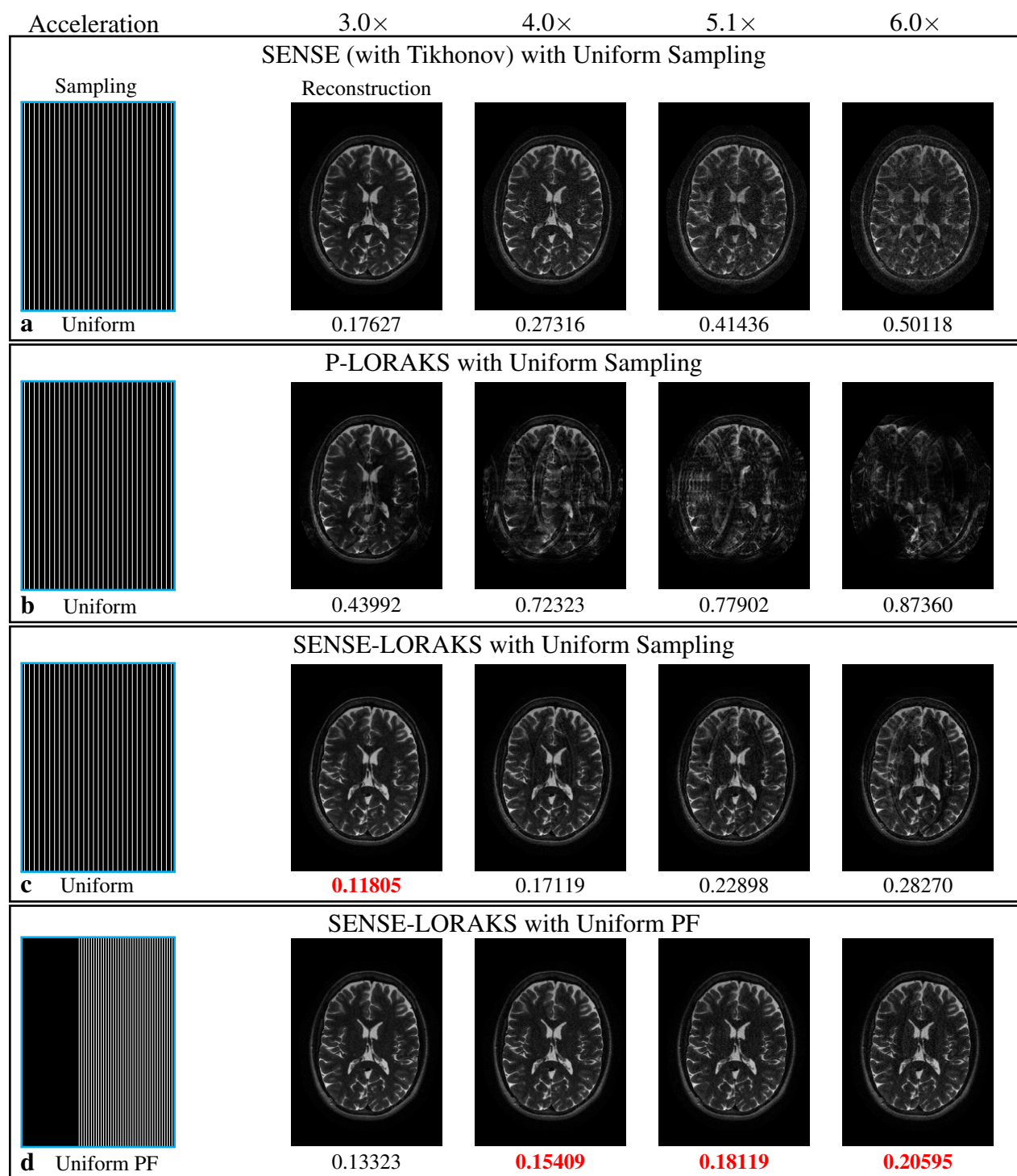


Figure S1: Reconstructed TSE images for a range of acceleration factors, presenting a detailed view of the results summarized in Figs. 2 and 4(a). Comparison between (a) SENSE with conventional Uniform sampling, (b) P-LORAKS with conventional Uniform sampling, (c) SENSE-LORAKS with conventional Uniform sampling, and (d) SENSE-LORAKS with Uniform PF sampling. Reconstructed images are shown using a linear grayscale (normalized so that image intensities are in the range from 0 to 1). NRMSE values are shown underneath each reconstruction, with the best NRMSE values highlighted with red. Corresponding error images are shown in Supporting Fig. S2.

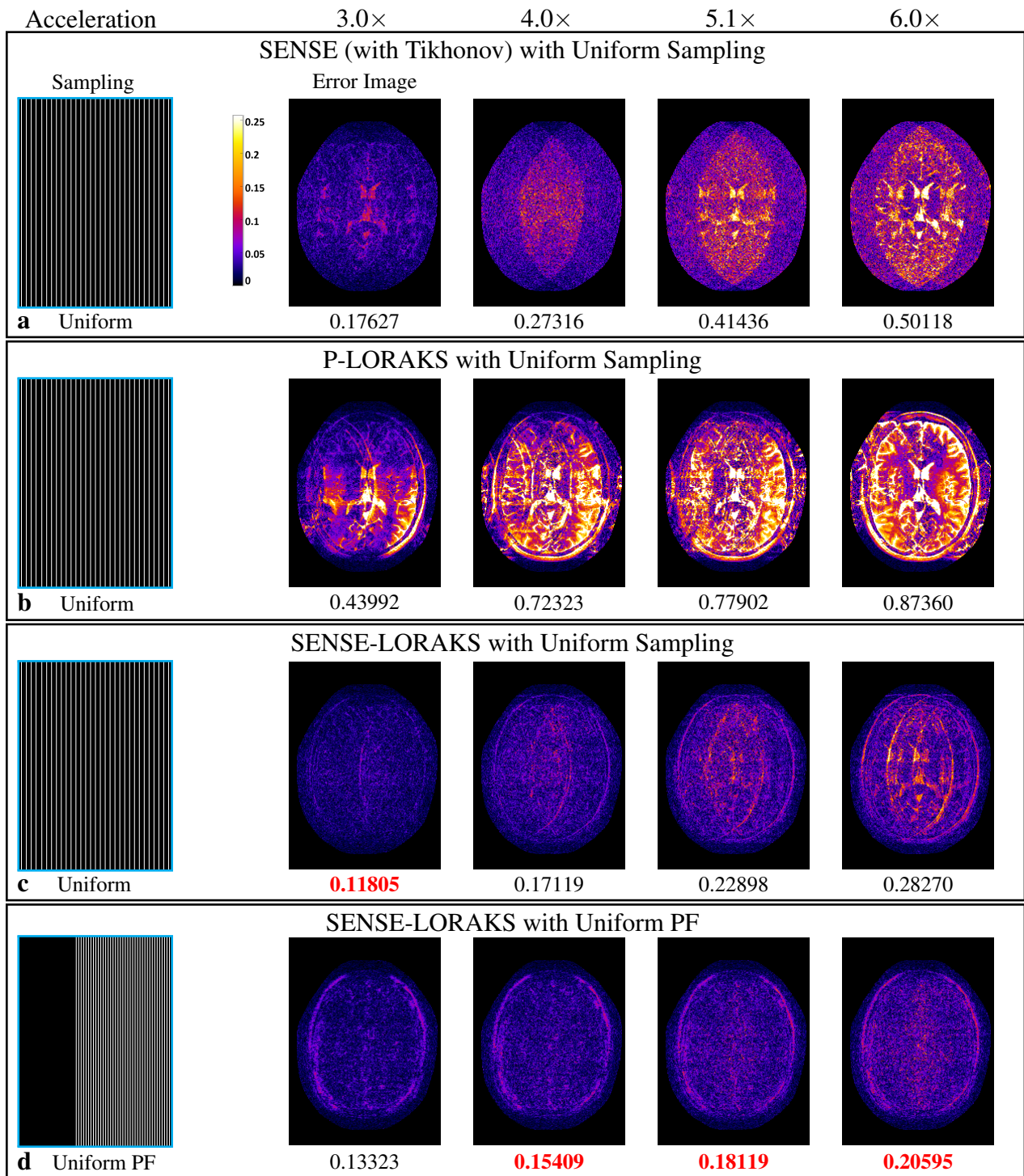


Figure S2: Error images corresponding to Supporting Fig. S1. Error images are shown using the indicated colorscale (which ranges from 0 to 0.25 to highlight small errors). NRMSE values are shown underneath each image where the smallest NRMSE values for a given acceleration rate are indicated in red.

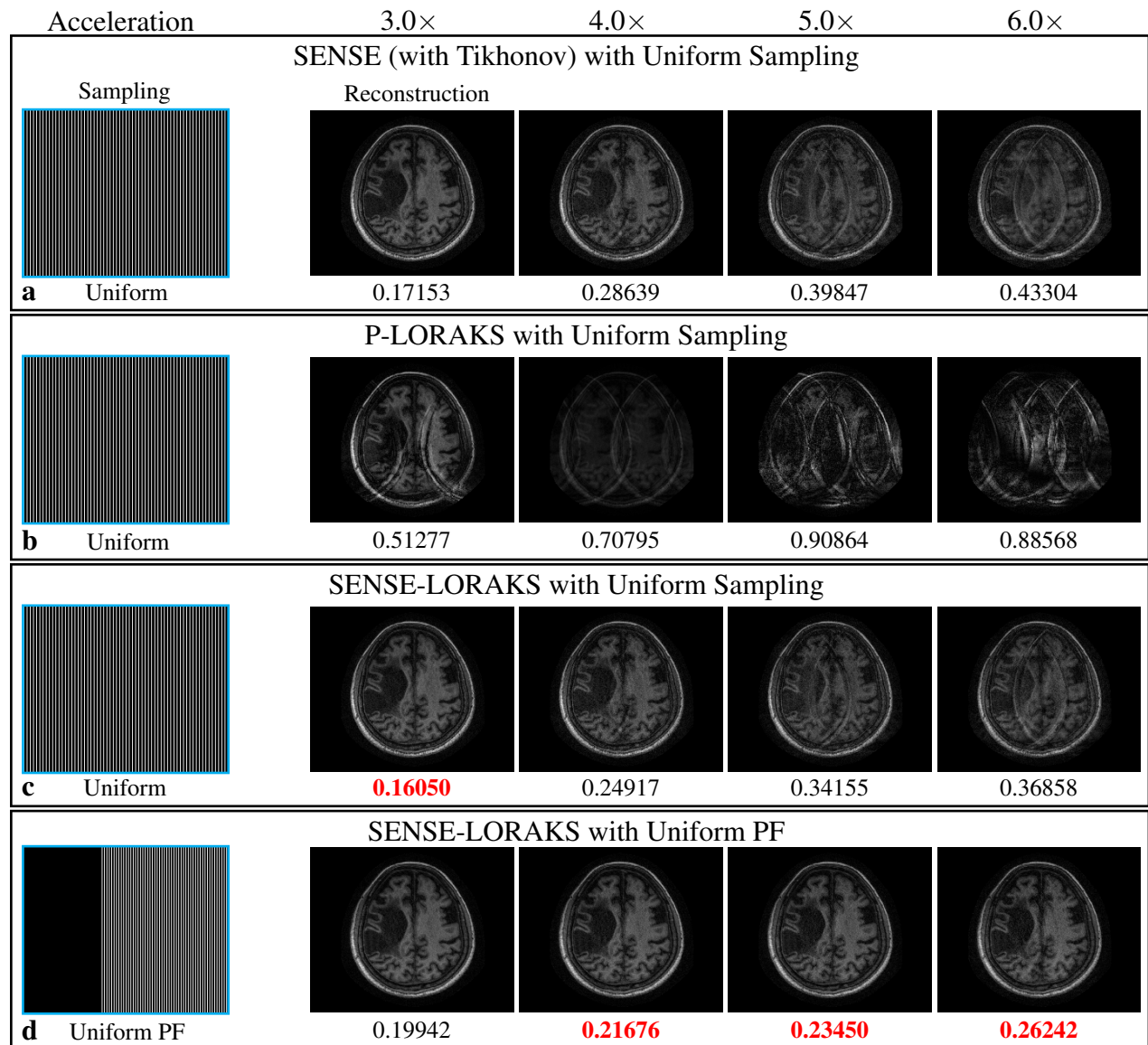


Figure S3: Reconstructed MPRAGE images for a range of acceleration factors, presenting a detailed view of the results summarized in Figs. 3 and 4(b). Comparison between (a) SENSE with conventional Uniform sampling, (b) P-LORAKS with conventional Uniform sampling, (c) SENSE-LORAKS with conventional Uniform sampling, and (d) SENSE-LORAKS with Uniform PF sampling. Reconstructed images are shown using a linear grayscale (normalized so that image intensities are in the range from 0 to 1). NRMSE values are shown underneath each reconstruction, with the best NRMSE values highlighted with red. Corresponding error images are shown in Supporting Fig. S4.

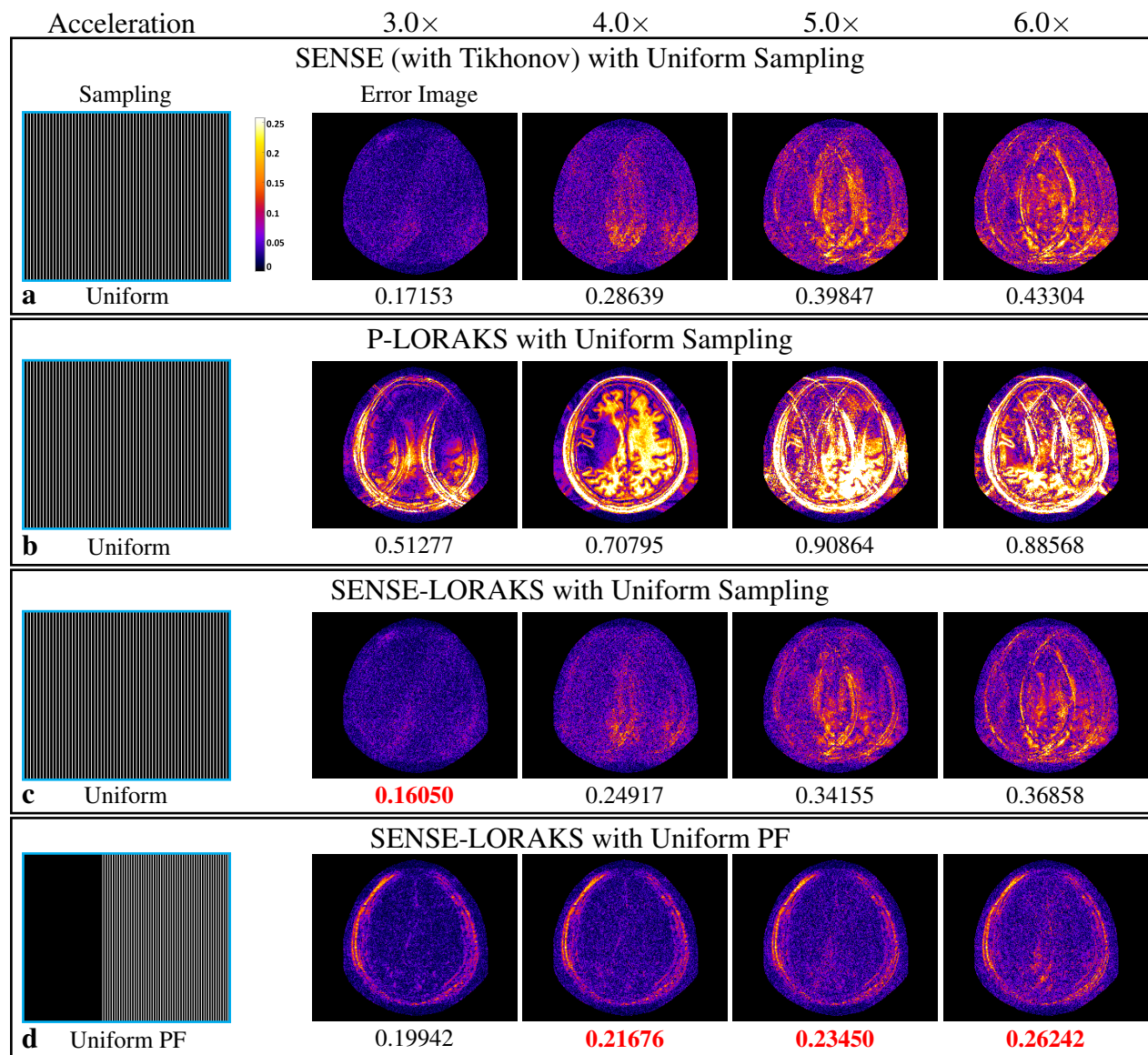


Figure S4: Error images corresponding to Supporting Fig. S3. Error images are shown using the indicated colorscale (which ranges from 0 to 0.25 to highlight small errors). NRMSE values are shown underneath each image where the smallest NRMSE values for a given acceleration rate are indicated in red.

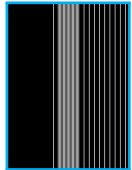
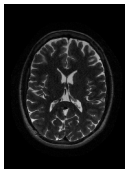
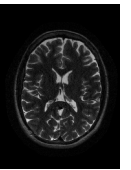
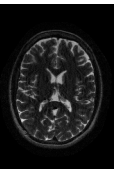
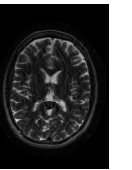
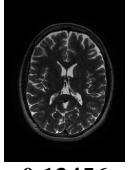
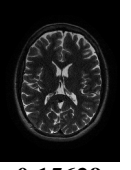
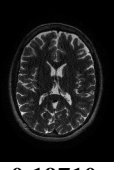
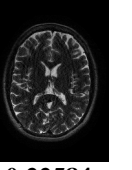
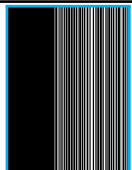
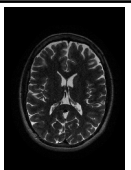
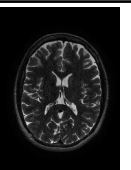
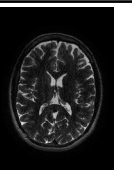
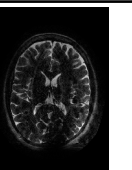
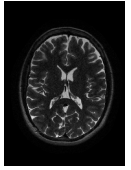
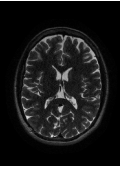
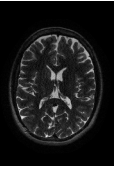
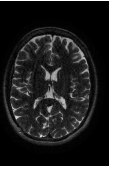
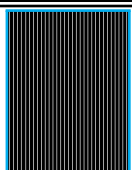
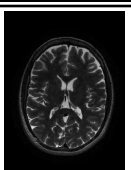
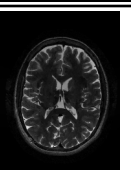
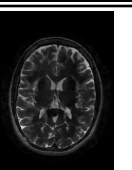
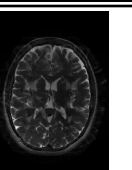
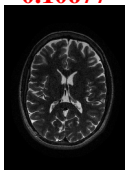
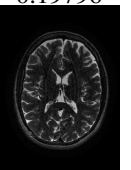
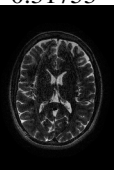
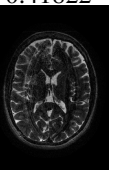
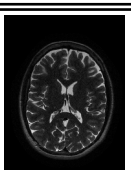
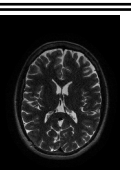
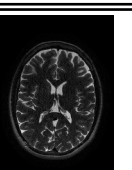
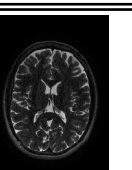
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a	SENSE-LORAKS				
		0.13456	0.15629	0.19710	0.22584
 Random PF	P-LORAKS				
		0.14229	0.17652	0.21510	0.45342
b	SENSE-LORAKS				
		0.13801	0.16158	0.19122	0.20879
 Uniform	SENSE+TV				
		0.10677	0.19796	0.31753	0.41822
c	SENSE-LORAKS				
		0.11805	0.17119	0.22898	0.28270
d	SENSE-LORAKS				
		0.13323	0.15409	0.18119	0.20595

Figure S5: Reconstructed TSE images for a range of acceleration factors, presenting a detailed view of the results summarized in Figs. 5 and 7(a). Comparison of images reconstructed using SENSE-LORAKS against (a) phase-constrained SENSE with AC PF sampling, (b) P-LORAKS with Random PF sampling, (c) SENSE+TV with conventional Uniform sampling. Reconstructions obtained using SENSE-LORAKS with Uniform PF sampling are shown in (d). Reconstructed images are shown using a linear grayscale (normalized so that image intensities are in the range from 0 to 1). NRMSE values are shown underneath each reconstruction, with the best NRMSE values highlighted with red. Corresponding error images are shown in Supporting Fig. S6.

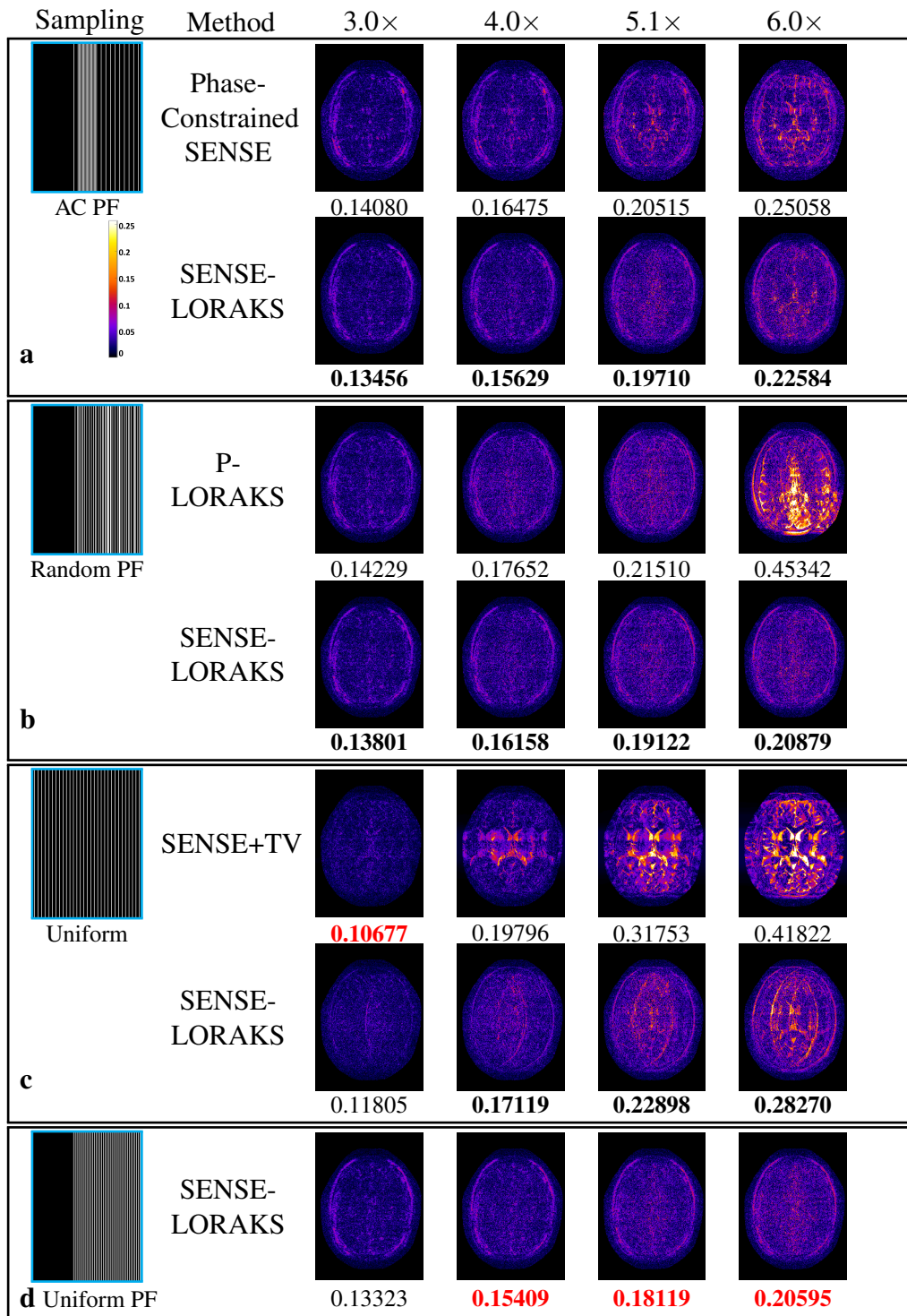


Figure S6: Error images corresponding to Supporting Fig. S6. Error images are shown using the indicated colorscale (which ranges from 0 to 0.25 to highlight small errors). NRMSE values are shown underneath each image where the smallest NRMSE values for a given acceleration rate are indicated in red.

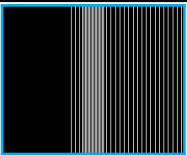
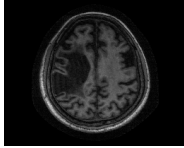
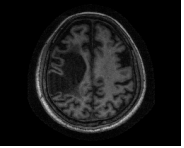
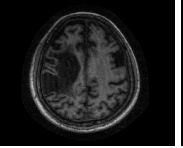
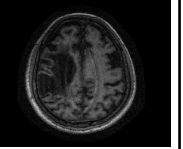
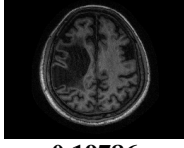

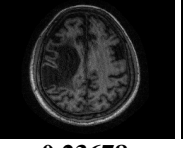
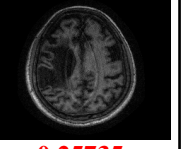
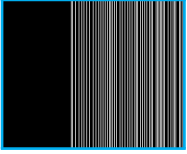
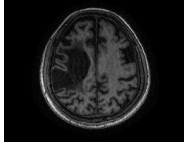
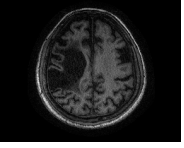
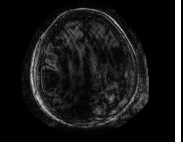
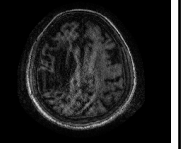
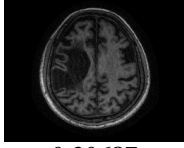
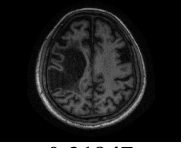
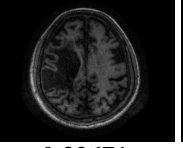
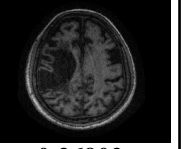
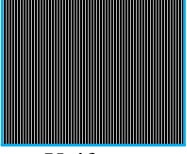
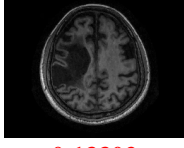
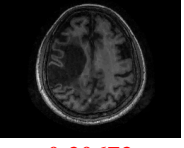
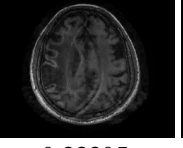
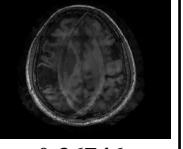
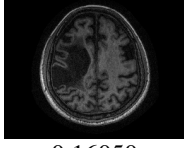
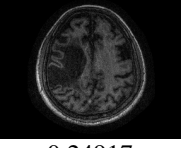
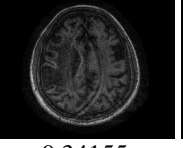
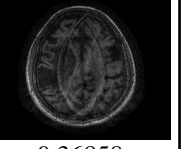
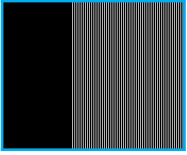
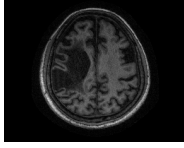
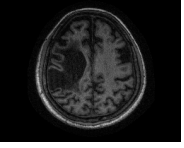
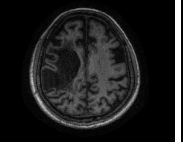
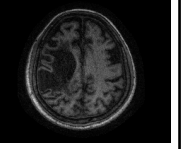
Sampling	Method	3.0×	4.0×	5.0×	6.0×
 AC PF	Phase-Constrained SENSE				
		0.20709	0.22236	0.24953	0.27789
a	SENSE-LORAKS				
		0.19786	0.21290	0.23678	0.25735
 Random PF	P-LORAKS				
		0.24522	0.28050	0.77941	0.44090
b	SENSE-LORAKS				
		0.20687	0.21947	0.32671	0.26902
 Uniform	SENSE+TV				
		0.13302	0.20672	0.33305	0.36746
c	SENSE-LORAKS				
		0.16050	0.24917	0.34155	0.36858
 Uniform PF	SENSE-LORAKS				
		0.19942	0.21676	0.23450	0.26242
d					

Figure S7: Reconstructed MPRAGE images for a range of acceleration factors, presenting a detailed view of the results summarized in Figs. 6 and 7(b). Comparison of images reconstructed using SENSE-LORAKS against (a) phase-constrained SENSE with AC PF sampling, (b) P-LORAKS with Random PF sampling, (c) SENSE+TV with conventional Uniform sampling. Reconstructions obtained using SENSE-LORAKS with Uniform PF sampling are shown in (d). Reconstructed images are shown using a linear grayscale (normalized so that image intensities are in the range from 0 to 1). NRMSE values are shown underneath each reconstruction, with the best NRMSE values highlighted with red. Corresponding error images are shown in Supporting Fig. S8.

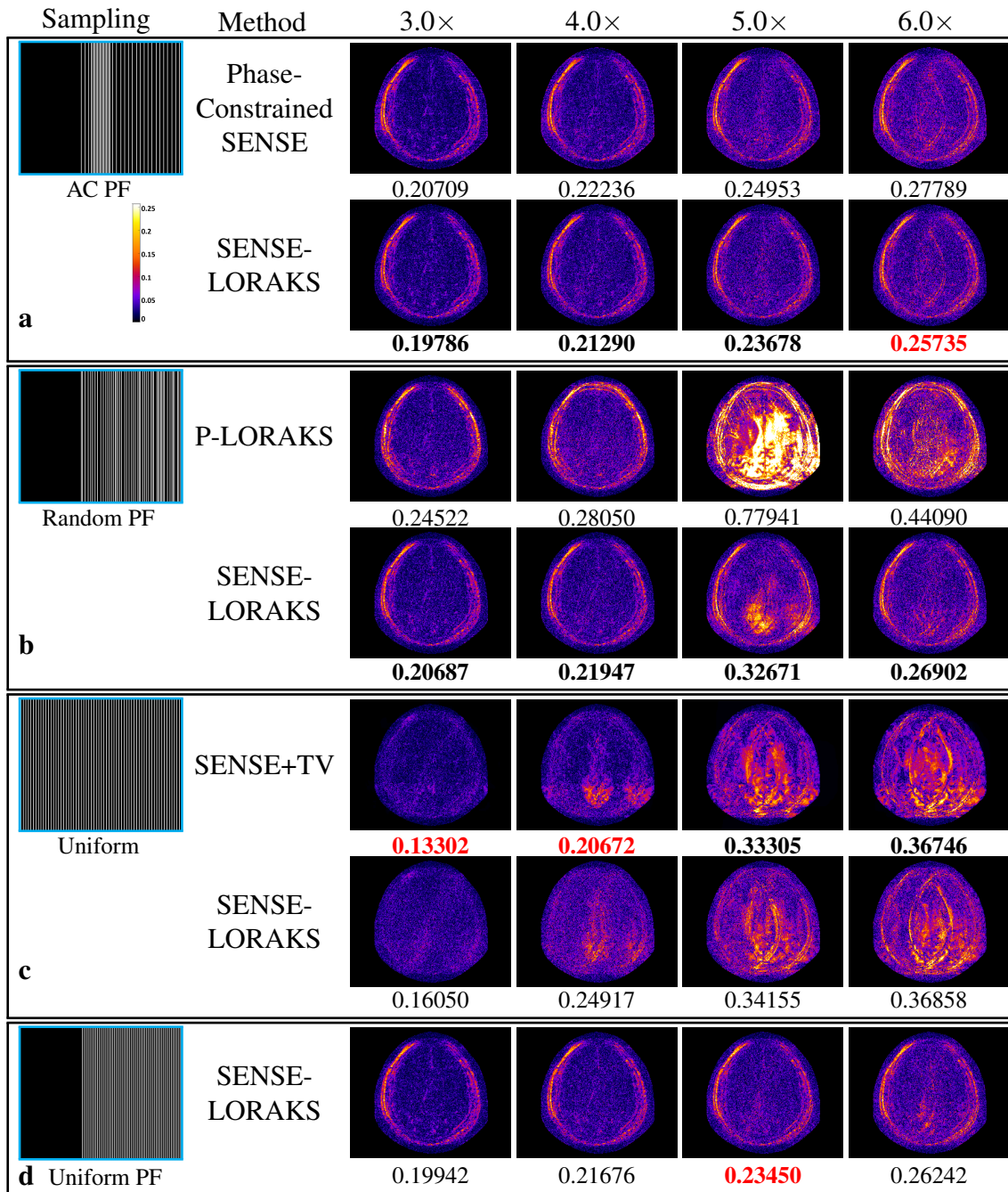


Figure S8: Error images corresponding to Supporting Fig. S7. Error images are shown using the indicated colorscale (which ranges from 0 to 0.25 to highlight small errors). NRMSE values are shown underneath each image where the smallest NRMSE values for a given acceleration rate are indicated in red.

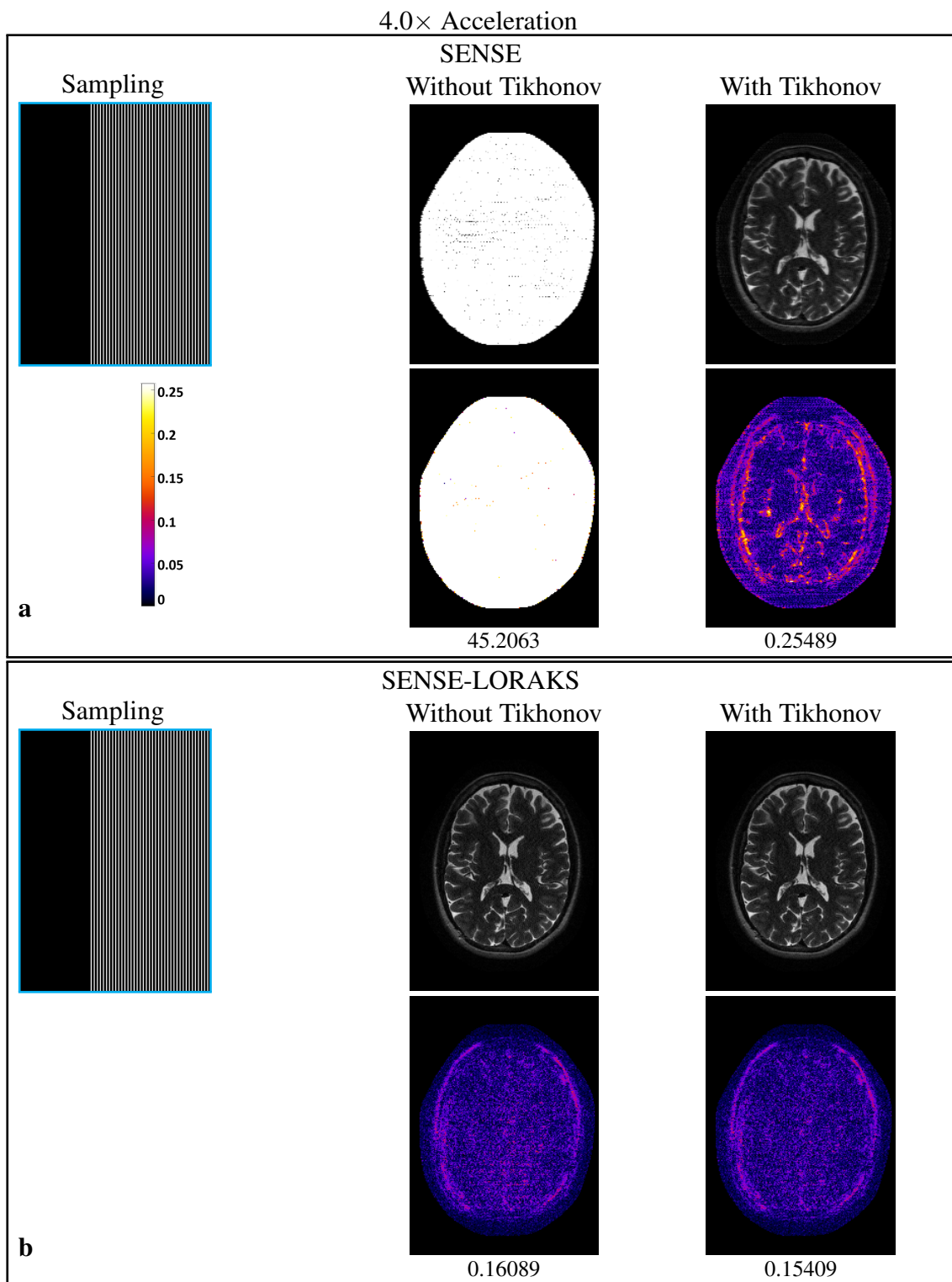


Figure S9: Illustration of the effects of Tikhonov regularization on (a) SENSE and (b) SENSE-LORAKS.

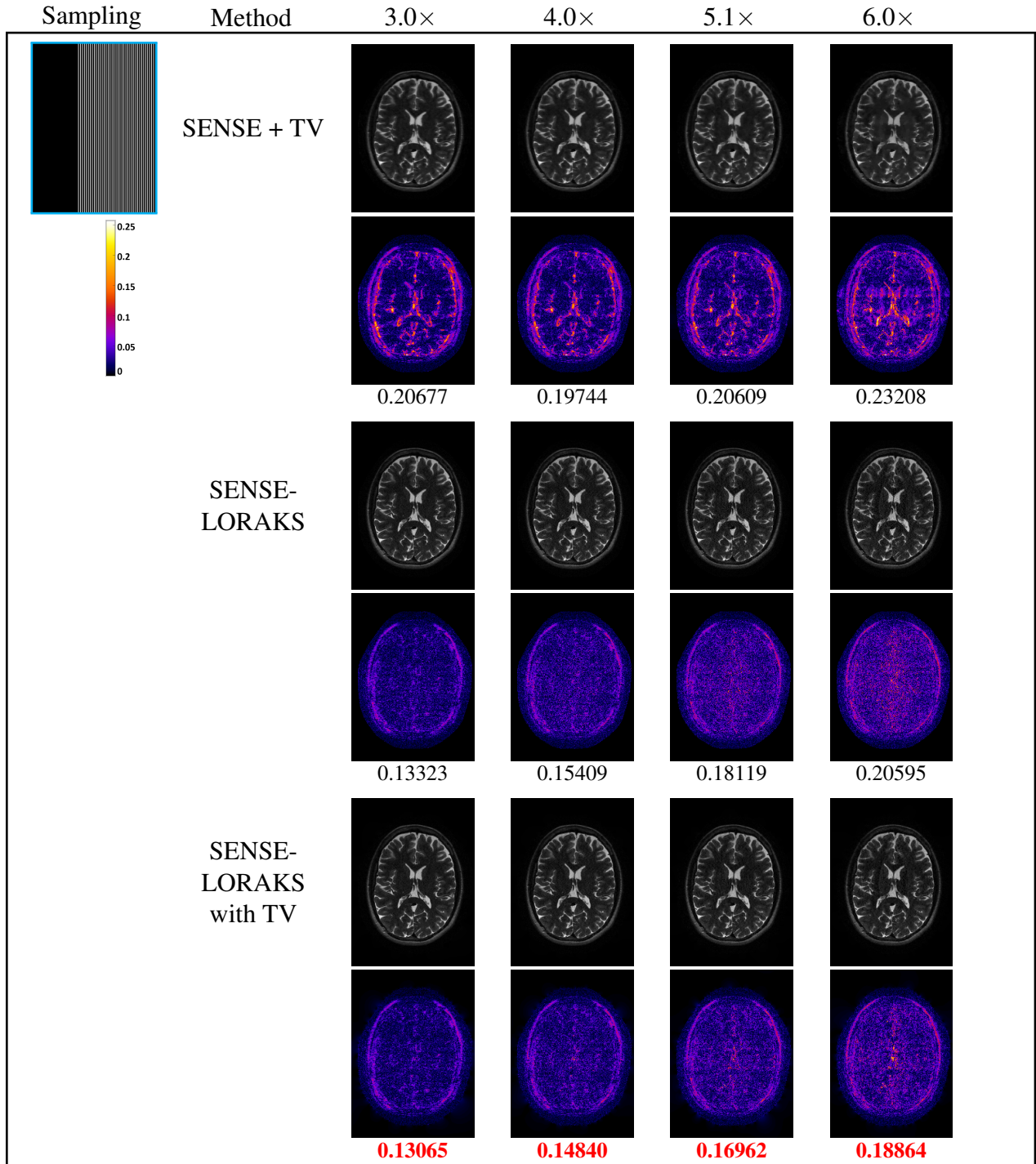


Figure S10: Comparison between SENSE+TV, SENSE-LORAKS, and SENSE-LORAKS with TV for TSE data with Uniform PF sampling. A subset of these results was shown in Fig. 10. The top rows show reconstructed images using a linear grayscale (normalized so that image intensities are in the range from 0 to 1), while the bottom rows show error images using the indicated colorscale (which ranges from 0 to 0.25 to highlight small errors). NRMSE values are shown underneath each reconstruction, with the best NRMSE values highlighted in red.