A Comparison of MP-RAGE Sequence Optimizations

Jinghua Wang[1], Lili He[2], and Zhong-Lin Lu[1]

[1]*Center for Cognitive and Behavioral Brain Imaging, The Ohio State University, Columbus, Ohio, United States,* [2]*Center for Perinatal Research, The Research Institute at Nationwide Children's Hospital, Ohio, United States*

Target Audience: Researchers and clinical practitioners who are interested in brain anatomy and morphometry

PURPOSE: MR images acquired with the magnetization-prepared rapid gradient echo (MP-RAGE) sequence have been widely used for classifying brain tissues in voxel-based morphometry, detecting pathological changes of the brain, estimating regional brain volume abnormalities associated with brain functions, assessing brain development, and evaluating treatment or therapeutic responses. Over years, many attempts have been made to optimize the MP-RAGE sequence to increase signal strength, enhance tissue contrast, reduce noise and obtain whole brain coverage in shorter scan time. In this study, we compare the signal-to-noise ratio (SNR) and GM-WM contrast-to-noise ratio (CNR) acquired using four different sets of optimized parameters recommended by: OSU [1], MGH [2], Siemens default and ADNI [3]. Both phantom and *in vivo* experiments suggest that image quality acquired with OSU parameters outperformed other candidates.

EXPERIMENTS: MRI scans of a uniform milk phantom (whose T_1 is very close to the average T_1 of gray matter and white matter [4]) and ten healthy adult subjects were acquired on a 3.0 T Siemens Trio-Tim system using a Siemens 32 channel head coil with the same resolution (FOV 232 x 256 mm^2, matrix 232 x 256, slice thickness 1mm) for all scans. The other imaging parameters are listed in Table 1.

RESULTS AND DISCUSSIONS: Images of a phantom and an adult brain along with corresponding noise distributions acquired using four different sets of optimized parameters are shown in Figures 1-4. The noise images were obtained by subtracting two images acquired with identical imaging parameters at two different time points. Visually, images acquired using parameters recommended by OSU exhibit the strongest signal intensities and lowest noise. Quantitative analysis indicates that the quality of images acquired with the OSU parameters outperformed others by more than 45% in terms of SNR efficiency and 36% in terms of GM-WM CNR efficiency for the brain images, and more than 140% in terms of SNR efficiency for the phantom images (Table 1). SNR and CNR efficiencies are defined as SNR and CNR per square root total scan time, respectively.

Table 1. Major imaging parameters and CNR and SNR efficiencies of a human brain, and mean signal intensity (SI), standard deviation (SD) of noise and SNR of a milk phantom at different imaging parameters.

	TI	FA	TR	Echo space time	*In vivo* adult subjects		Milk phantom		
	(ms)	(degree)	(ms)	(ms)	SNR efficiency	CNR efficiency	Mean SI	SD	SNR
OSU	950	12	1950	10.1	5.60	1.90	275	3.01	91.3
MGH	1200	8	2530	7.9	3.86	1.39	146	3.88	37.6
Siemens	900	9	2300	7.1	3.89	1.38	115	4.34	26.5
ANDI	850	9	2200	7.1	3.90	1.38	111	4.21	26.3

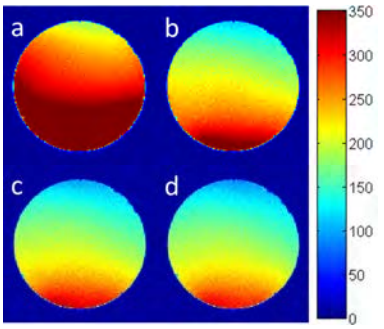

Fig.1 Milk phantom images acquired with different optimized parameters recommended by: OSU (a), FreeSurfer (b), Siemens default (c), and ADNI (d).

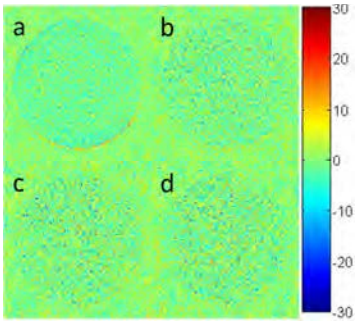

Fig. 2 Noise in images of a milk phantom acquired with different optimized parameters recommended by: OSU (a), FreeSurfer (b), Siemens default (c), and ADNI (d).

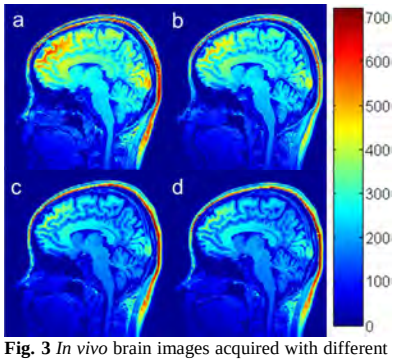

Fig. 3 *In vivo* brain images acquired with different optimized parameters recommended by: OSU (a), FreeSurfer (b), Siemens default (c), and ADNI (d).

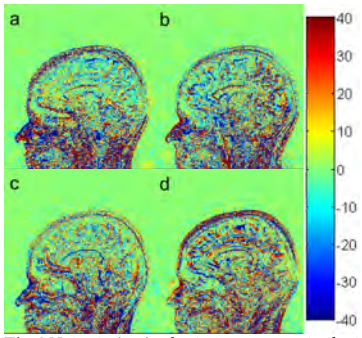

Fig.4 Noise in *in vivo* brain images acquired with different optimized parameters recommended by: OSU (a), FreeSurfer (b), Siemens default (c), and ADNI (d).

CONCLUSIONS:
As one of the most popular sequences for structural brain imaging in clinical and research settings, the MP-RAGE sequence has drawn increasing attention. In this study, we evaluated the performance of 4 different sets of optimized imaging parameters of the sequence. Our results suggest that the quality of the images acquired with the parameters recommended by OSU was significant better than that of images acquired with other recommended parameters. The optimization procedure and resulted parameters recommended by OSU may hold great potential in reducing variability of images acquired across different sites and/or over time. The reduced variability is crucial for increasing the statistical power and reducing the number of required subjects in basic and clinical research.

REFERENCE:

1. Wang J et al. PLOS ONE. 2014;9: e96899
2.https://surfer.nmr.mgh.harvard.edu/fswiki/FreeSurferWiki?action=AttachFile&do=get&target=FreeSurfer_Suggested_Morphometry_Protocols.pdf
3. Jack CR et al. J. Magn. Reson. Imaging 2008;27: 685.
4. Wang J et al. J Magn Reson. 2006; 182 (2):283.