Improved Image Quality with PROMO-enabled Multi-Echo Enabled MP-RAGE

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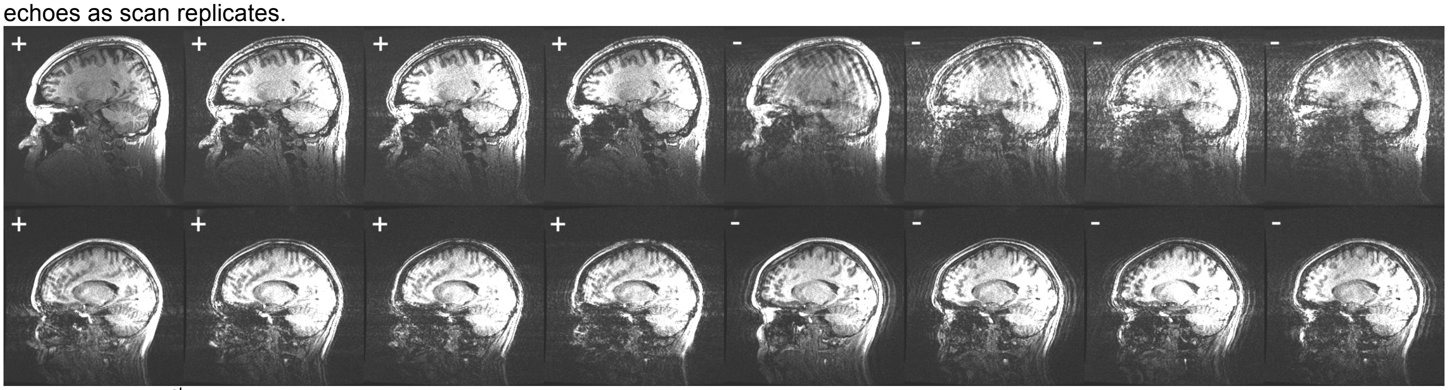
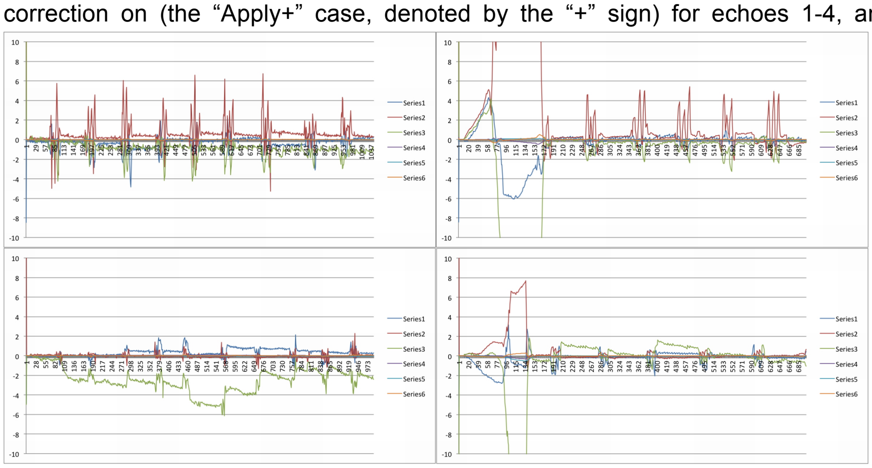
Introduction: Prospective motion correction techniques that have recently become available promise improved MR image quality, and therefore improved reliability of the metrics derived from data that utilize such techniques. In this work, a PROMO-enabled [1] MP-RAGE sequence has been enabled with multi-echo capability. Data acquired with this sequence was then analyzed with FreeSurfer, and consistency of this data was compared to results acquired with the same sequence, but with PROMO corrections not applied.

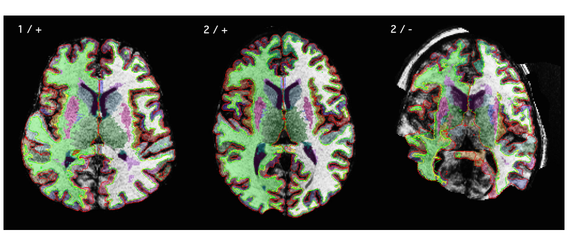
Methods: Data were acquired from 3 healthy adults (2F, 1M) on a 3T MR scanner with a 32-channel head coil, utilizing a multi-echo PROMO-enabled 3D MP-RAGE sequence. The parameters used for this sequence were: TR = 11ms, 4 echoes acquired at TEs = 1.9/3.8/5.8/7.7ms, BW = 83.33 kHz, IR = 1150ms, FA = 7°, 1x1x1mm, ARC (parallel imaging factor) = 2. Subjects were instructed to perform a figure-eight motion with their nose 3 times every 60s, by their count. Separate scans with intentional subject motion were acquired with (the "Apply+" case) and without (the "Apply-" case) PROMO motion correction applied. Regional cortical thickness and volume were calculated using version 5.3 of FreeSurfer [2], to try to determine consistency of these metrics, using the 1st and 3rd echoes as scan replicates.



Results: The 1st figure above shows images obtained from 2 subjects (1 per row). The first 4 images per row are with the PROMO correction on (the "Apply+" case, denoted by the "+" sign) for echoes 1-4, and the 2nd 4 images per row are with the PROMO corrections turned off (the "Apply-" case, denoted by the "-" sign) for echoes 1-4. For 2 of the 3 subjects, results are qualitatively very similar to the first row, where motion artifacts in the MP-RAGE images are noticably different (and reduced) with the application of PROMO corrections. With the 3rd subject, there was a small improvement in image quality with the reduction of ringing image energy in the background, but the overall improvement is not as drastic as with the other 2 subjects. The 2nd figure shows the motion plots computed from the PROMO navigator images. The location of the sub-graphs match up with how results are presented in the first figure, i.e. the first row is from subject 1, with and without PROMO, with the 2nd row representing subject 3, again with and without PROMO, respectively. It is postulated that the reduced efficacy of PROMO corrections in the "Apply+" experiment for subject 3 could be due either to the constant drift (seen in the green trace) in this subject's motion traces, or the reduced detected amplitude of their motion.



The figure below shows results obtained from FreeSurfer. The pipeline completed segmentation and provided only a complete set of results for subjects 1 and 2 in the "Apply+" case (denoted as "1/+" and "2/+" in that figure) and for subject 2 in the "Apply-" case (denoted by the "2-" label). However, the results from the successfully completed "Apply-" case are not usable, as seen by the quality of the skull-stripping and surface detection in the sub-figure labeled "2/-". For subject 3, neither the "Apply+" or "Apply-" case produced data with which FreeSurfer could complete analyses. Because of the reduced set of completed FreeSurfer analyses, there was insufficient data to compute statistics.



Discussion: As with successful implementation and use of other prospective motion compensation techniques, the use of PROMO for MP-RAGE shows qualitative improvements in all echo images. These results also indicate that it might be possible to improve tissue classification using high-resolution anatomical images for conditions for patients with motion control disorders, such as Parkinson's Disease or Multiple Sclerosis, where motion compliance for MR imaging can be challenging. Images, such those acquired here with prospective motion compensation, have the possibility to provide better T2* estimates (e.g. by fitting the signal intensity in the gradient echo train to a mono- or multi-exponential decay) of the under-lying tissue, as well as better estimates of other metrics of tissue property that can be derived from MR data. This increases the potential of MRI to provide a better picture of what might be happening to the underlying tissue in such types of diseases.

References: [1] White, *et. al.*, MRM, 63:91-105, 2010. [2] Fischl, *et. al.*, Neuron, 33:341-355, 2002.