The optimization of B1 insensitive T1 weighted MP2RAGE sequence at high field.

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Target audience: high field users

Purpose: At high magnetic field (≥7T), large spatial B1 inhomogeneities cause non-uniform signal intensity across an image volume. This artifact causes a large bias in T1 weighted 3D MPRAGE images [1]. To overcome the image bias due to B1 inhomogeneity, several approaches have been proposed [2, 3]. MP2RAGE has shown the potential to minimize B1 variation in T1-weighted images by using two GRE acquisitions with different flip angles after the inversion pulse [3]. A previous study showed that a long TR (>8s) would provide high signal to noise ratio (SNR) and contrast to noise ratio (CNR) in MP2RAGE by providing the large dynamic contrast range for inversion recovery. However, this leads to a relatively long scan time. In this study, we optimize MP2RAGE parameters with different TR values to generate T1 weighted contrast at 7T with 10% image non-uniformity in brain tissues. A healthy subject was scanned with the optimized parameters with different TRs at 7T. Brain segmentation was conducted using acquired MP2RAGE images and the results were compared.

Methods: A simulation was conducted using a modified version of ref. [3]. Flip angles were varied from 1° to 12°, and time gap between RFs, τ, was fixed at 6ms. Z-directional 28th phase encoding (PE) during gradient refocusing echo (GRE) acquisition (Nz = 176) was assumed so that the duration of each acquisition is 1056ms. T1I, T12, and T2 were varied in 100ms steps within a fixed TR (from 4s to 8s with a step of 0.5s). MP2RAGE contrast was simulated with T1 range from 500ms to 5000ms, and T1 of white matter (WM), gray matter (GM) and cerebral spinal fluid (CSF) were roughly assumed with 1, 2, and 4.5s [6]. Contrast to noise ratio (CNR) per unit time (divided by the root of TR) between WM and GM (CNRWG), and GM and CSF (CNRCsf) were calculated [3]. B1 inhomogeneity of ±40% at 7T was simulated [3] and it was assumed that the only actual flip angle is determined by B1 homogeneity (e.g. actual FA = B1 efficiency × input flip angle). Signal offset was calculated as (MP2RAGEWM - MP2RAGECSF) / (MP2RAGEWM - MP2RAGEGM). The optimized parameters for MP2RAGE within a fixed TR were chosen: 1) optimizing CNRWG. The optimized parameters for MP2RAGE within a fixed TR were chosen: 1) the same reason, it is not surprising that the resulting optimized parameters of MP2RAGE are different with ones in ref. [3]. In the experimental setting examined here, a TR of 4s generates reasonably good contrast in brain tissue, and results in good segmentation of WM and GM.

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Reference

Fig 1. Plot of TR vs max CNR

Fig 2. Representative MP2RAGE images and enlarged area with different TR. Since dynamic ranges of MP2RAGE contrast with different TRs vary, image are re-scaled with (MP2RAGEWM - MP2RAGECSF) / (MP2RAGEWM - MP2RAGEGM) and displayed from -1 (black) to 1.5 (white).

Fig 3. Example of brain segmentation result using MP2RAGE images with different TR.

Tab1. The optimized parameters of MP2RAGE. Maximum signal offset is shown from ±40% of B1 efficiency.