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CNR Comparison of Three Pulse Sequences for Structural MR Brain Imaging

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Objective: Accuracy of quantitative MR imaging-based neuroanatomical study is inherently limited by the acquired image quality such as resolution, distortion, and contrast-to-noise-ratio (CNR). A high-bandwidth multi-echo FLASH (MEF) sequence was recently developed by our group that allows significant reduction in image distortion while maintaining high image SNR [1]. In this work, we further investigate the ability of this new pulse sequence to differentiate multiple brain structures by comparing the image CNR against two commonly used sequences: the single echo FLASH (seFLASH) [2] and the MPRAGE [3].
Methods: *Data Acquisition*: 12 subjects were scanned at a Siemens 1.5T MR scanner. In each scan session the following data were acquired: two MPRAGE volumes (averaged afterwards after motion-correction) (190 Hz/pixel, TR/TE/TI = 2.73s/3.44ms/1s, flip angle = 7^o); two multiple flip angle (30^o and 5^o) seFLASH volumes (TR = 20ms, TE = 6ms); and two multiple flip angle (30^o and 5^o) MEF volumes (651 Hz/pixel, TR = 20ms, TE = $(1.8+1.82*n)$ms, n=0~7) [1]. The acquisition time and image resolution were the same for each pulse sequence.

Manual labeling: To evaluate CNR, manual segmentation was performed to generate underlying tissue labeling [4]. Due to time-limitation, manual labeling was generated only for 7 of the 12 MEF datasets, 5 MPRAGE, and 4 seFLASH.

CNR computation: We used Mahalanobis distance to evaluate CNR for both averaged MPRAGE images and multi-spectral seFLASH and MEF images:
$CNR(i,j)= \sqrt{(\mu_i - \mu_j)^T((\Sigma_i + \Sigma_j)/2)^{-1}(\mu_i - \mu_j)}$,
where μ and Σ represent class mean and covariance matrix respectively.

Results & Discussion: We computed CNR across different pairs of major brain structures and Figure 1 shows the results. In general, MEF is significantly better than seFLASH in differentiating all pairs of brain structures. Although the gray/white CNR is slightly lower, MEF is significantly better than MPRAGE in differentiating various subcortical structures. In a separate study (reported in a separate abstract by Jovicich *et al.*), it is also shown that MEF has significantly less intensity variation across multiple scans of the same subject. The improved CNR, reduced intensity variation, and reduced image distortion render a great advantage of using the MEF pulse sequence in MR imaging-based brain morphometry studies.
Conclusions: The MEF sequence gives the best overall acquisition efficiency among all three sequences compared. The good CNR across all brain structures and its ability to allow the calculation of intrinsic MR tissue parameters (T1, T2* and proton-density) [1] enables a wide range of neuroscience studies. Work remains to be done, however, to most effectively use the high-dimensional multi-spectral MEF image data to improve brain segmentation and morphometric analysis. The effect of reduced gray/white CNR (than MPRAGE) on surface-based cortical analysis is also worth further investigation.
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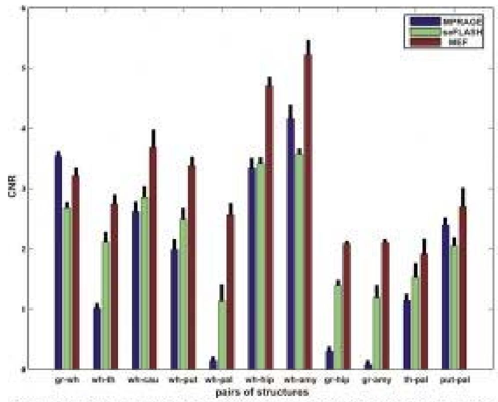

Figure 1. CNR comparison of three pulse sequences on 11 pairs of brain structures. The bar plot shows the average CNR across subjects for each group, and the error-bar indicates one standard deviation. Structures involved are: *gray-matter* (gr), *white-matter* (wh), *thalamus* (th), *caudate* (cau), *putamen* (put), *pallidum* (pal), *hippocampus* (hip), and *amygdala* (amy).