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Test-retest reliability assessment for longitudinal MRI studies: An intensity-based comparison of T_1-weighted protocols and field strengths

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Introduction:

Longitudinal MRI studies offer the potential to quantify changes in brain structure over time in neurodegenerative diseases, such as Alzheimer's disease, and may ultimately provide useful biomarkers of disease progression [1]. An important challenge for such studies is to minimize instrumentation-related variability in the images, thereby reducing noise and increasing power to detect potential biologic effects of interest [2]. We undertook this study to obtain estimates of variance present in imaging data when healthy older subjects are scanned at two week intervals on the same scanner and on different scanners at different field strengths. This initial analysis focused on the reproducibility of image intensity, which may affect tissue classification/segmentation regardless of which particular morphometric analysis approach is used. An accompanying abstract presents our investigation of reproducibility of morphometric measurements.

Methods:

Fifteen healthy older subjects were each scanned, two weeks apart, twice on Siemens Sonata 1.5T, once on Siemens Trio 3T, and once on GE Signa 1.5T. Only Siemens data are presented. In each Siemens session, the acquisition included two MP-RAGE volumes (190Hz/pixel, FA= 7^0, 1.5T:TR/TE/TI=2.73s/3.44ms/1s, 3T:TR/TE/TI=2.53s/3.25ms/1.1s) and two multi-echo multi flip angle (30^0 and 5^0) FLASH volumes (651 Hz/pixel, TR=20ms, TE=(1.8+1.82**n*)ms, n=0-7; both for 1.5T and 3T) [3]. All scans were 3D sagittal acquisitions (256x192, 1.33mm thick, 128 sagittal slabs).

Each scanning session was summarized by two volumes: an averaged MP-RAGE scan and a T1-weighted synthetic FLASH image [3]. Each average was skull stripped, co-registered with a paired reference scan, and intensity normalized (brain mean=100). For each subject we computed voxel-based relative error maps (image intensity difference) and error histograms for 1.5T-1.5T test-retest (2 sessions on Sonata, with and without 3D distortion corrections for gradient non-linearities [2]) and 1.5T-3T test-retest (one session on each). Mean image intensity errors were computed from the histograms for each of the subjects, and then averaged across subjects.

Results and discussion:

Mean image intensity variability across subjects was:

1.5T-1.5T: for MP-RAGE 6% (no change after distortion correction) and for multi-echo FLASH 4.5% (significantly improved to 3.9% with distortion correction);

1.5T-3.0T: for MP-RAGE 11% (no change after distortion correction) and for multi-echo FLASH 7.9% (improved to 7.3% with distortion correction).

Conclusions:
These results suggest that for a longitudinal study using T1-based sequences, a component of the variance may be due to variability in intensity alone. Although the variance of some morphometric measures is less than the variance of mean image intensity (see accompanying abstract), methods to reduce this variance may improve the power of morphometric studies to detect biological effects, such as volumetric change over time. Work is ongoing to reduce intensity variability, to analyze the effects of intensity variability on morphometric measures, and to combine data acquired at different field strengths and other platforms.

References:
[1] Ashburner J et al. Lancet Neurol 2003;79-88
[2] Jovicich J et al. ISMRM 2004
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