Neuroscience Campus Amsterdam

The hippocampal boundary shift integral is 70% more reproducible than FreeSurfer, manual and other hippocampal atrophy measurement algorithms

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Purpose To compare the reproducibility and accuracy of hippocampal atrophy measurements using ADNI1 back-to-back (BTB) [1] MPRAGEs from the ADNI1 data set [2] for FreeSurfer/ReconAll 5.3.0, FSL/FIRST 5.0.4, AdaBoost, MAPS [3], MAPS-HBSI [3] and manual [4].

Methods ADNI1 acquired two identical MPRAGEs at each patient visit (referred to as M and N) making it ideal for BTB assessment of the reproducibility [1,2] and accuracy of hippocampal atrophy. For baseline and year 1, a representative subset of N=75 subjects was selected from ADNI1 with 19 healthy controls (HC), 38 mildly cognitively impaired (MCI) and 18 Alzheimer's disease (AD) [4]. The percentage volume change (PVC) between baseline and year 1 was calculated using each of the 6 algorithms for both the M and N MPRAGEs. To determine the reproducibility, the BTB difference (BTBD) was calculated for the left hippocampus for each patient and each algorithm by PVC_N-PVC_M. ADNI1 also selected one of M and N for additional processing generating a modified MPRAGE referred to as P.

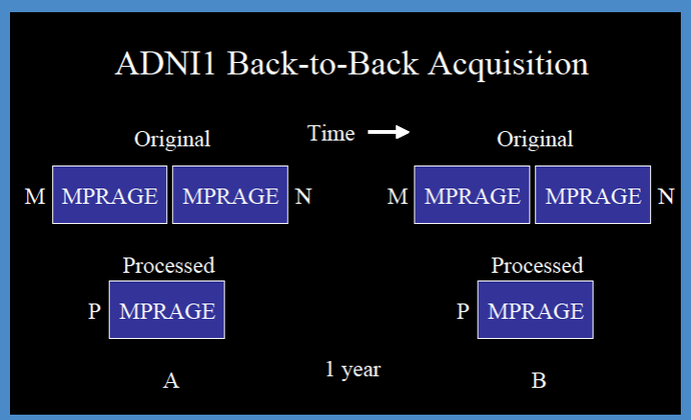

Figure 1. ADNI1 back-to-back (BTB) MPRAGE component

As a novel way to measure accuracy and noise of the PVC, the annualised PVC for the left and right hippocampi were scatter plotted based on the hypothesis that in HCs they should be symmetric [5].

Results Figure 2 shows the left-right PVC scatter plots for 3 algorithms for MPRAGEs M, N and P. Comparison among M, N and P shows little difference indicating the ADNI1 post processing included in P had little effect on the noise. Comparison among the 3 algorithms clearly shows all algorithms have roughly the same range of signal but MAPS-HBSI has substantially less noise. The 2 algorithms not shown had similar scatter plots to FreeSurfer and manual.

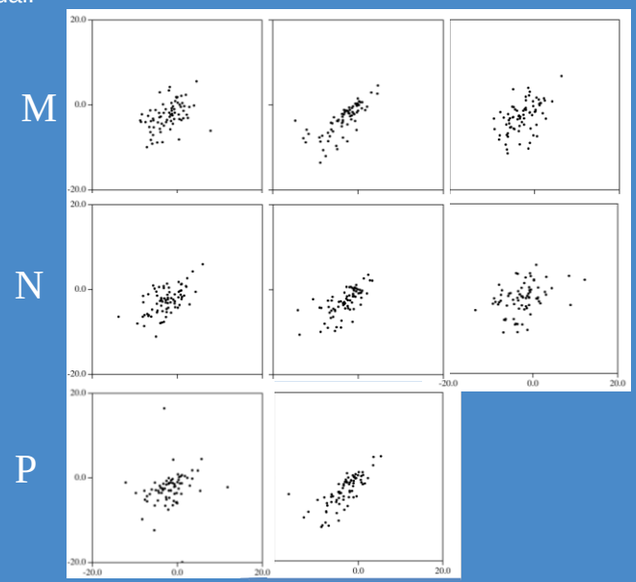

Figure 2. Left-right symmetry scatter plots for MPRAGEs, unprocessed (M & N) and ADNI1 processed (P). The symmetry breaks down at higher atrophy rates (more negative PVCs) due to the AD patients [5].

The BTBD scatter plots in Figure 3 clearly demonstrate the BTBD were larger for FreeSurfer and manual than MAPS-HBSI. The number of BTBD differences were smaller for MAPS-HBSI than for each of the other 5 algorithms ($p<0.002$). The BTBD 50 percentile spread was at least 70% smaller for MAPS-HBSI than for all the other algorithms.

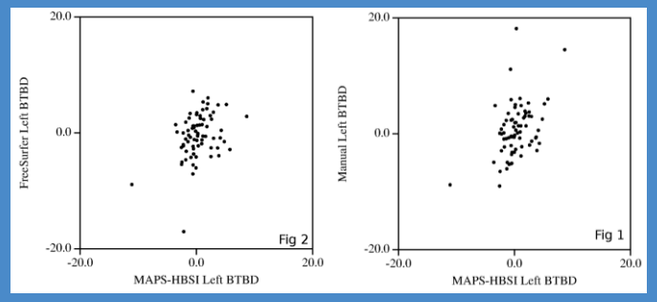

Figure 3. Scatter plot of BTB differences of FreeSurfer and manual versus MAPS-HBSI

Conclusions

- MAPS-HBSI is roughly 70% more reproducible, based on BTB, than FreeSurfer, manual and the other algorithms
- ADNI1 post processing does not introduce significant noise based on the left-right symmetry of annualised PVC scatter plots
- The improved atrophy measurement is a step closer to hippocampus atrophy as a biomarker for individuals in AD

References: [1] Smith SM et al. NeuroImage 2007;36,1200. [2] Cover KS, et al. Psychiat Res-Neuroim 2011;193:182. [3] Leung, KK, et al. NeuroImage, vol 51, pp. 1345-1359. [4] Mulder ER et al. Neuroimage 2014;92:169-181. [5] Fox et al. Brain 1996;119:2001-200.

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