PROBABILISTIC HUMAN BRAIN ATLAS: PART 2, VALIDATION WITH ADNI DATA

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Introduction

Due to the importance of quantitative region-based analysis in functional imaging and the need for more feasible methods in routine clinical use, we quantified the errors associated with using automatically generated VOIs from a probabilistic human brain atlas for estimating regional PET uptake values in part 1 of the study (see poster 1597).

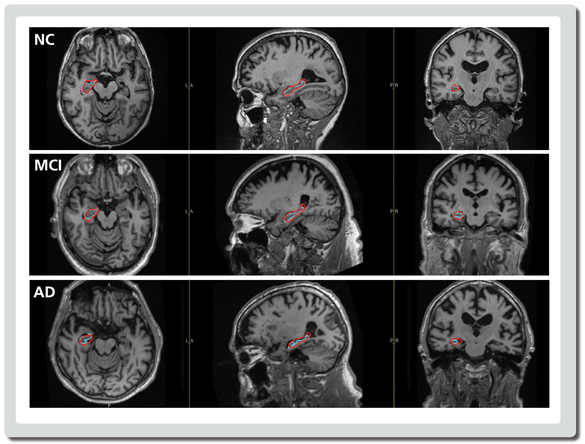
Objectives

The purpose of part 2 was to validate the suitability of using the probabilistic atlas for automated hippocampal region analysis on the Alzheimer's Disease Neuroimaging Initiative (ADNI) data as a surrogate for manual VOI definition on co-registered MRI images.

Methods

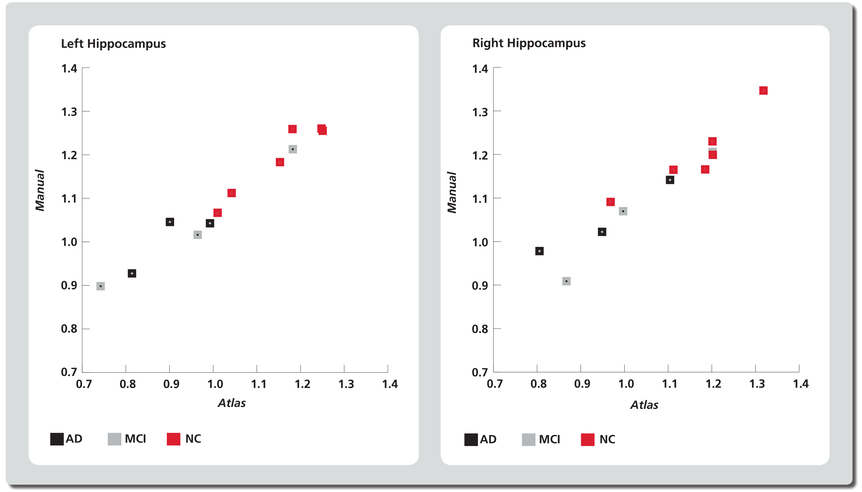
- A probabilistic hippocampal atlas was created from the hippocampal regions for the 10 subjects who received T1-weighted MRI and PET scans from part 1 of the study.
- Twelve subjects with T1-weighted MRI and FDG PET brain scans were used from the ADNI database
  - Six normal controls (NC)
  - Three subjects with mild cognitive impairment (MCI)
  - Three subjects with Alzheimer's disease (AD).
- For each ADNI subject, hippocampal VOIs were defined on the MRI and co-registered to the PET scan to serve as the gold standard VOI for each subject.
- Median uptake values were determined for each gold standard VOI and probabilistic atlas VOI using a region from the pons for normalization.
- Linear regression was used to determine the probabilistic levels which best predicted the gold-standard values.

Figure 1
Manual vs. Atlas VOIs



Atlas VOI segmentation was performed directly on the PET volume - the MRs are displayed only for reference. Manually delineated VOIs are shown in blue and atlas VOIs (5/10) are shown in red. Gross anatomic differences are corrected by the registration and probabilistic nature of the atlas. Local atrophy is corrected by the slope of the regression line. In this case, a slope of 1.22 produced a coefficient of determination (R^2) of 0.92.

Figure 2
Atlas Estimation Fit



The predictive value of the atlas estimated regional uptake was excellent for the gold standard regional uptake. Both atlas and manual right hippocampus VOIs separated AD from NC with 100% accuracy. Both methods misclassified one subject using the left hippocampus (88% accuracy). The distribution of MCI subjects was also very similar using both manual and atlas segmentation.

Results

The left hippocampal gold standard and 10/10 atlas VOI readily separated the NC and AD groups (t-test at p=0.008 and p=0.007 respectively).

The right hippocampal gold standard and 5/10 atlas VOI also separated NC and AD but with less statistical significance (t-test at p=0.03 and p=0.06, respectively).

The left atlas hippocampal VOI was also more consistent with the subject VOI with coefficients of determination (R2) of 0.96 and 0.92 respectively.

Two of the MCI subjects were indistinguishable from AD and one from NC using the hippocampal region alone.

Figure 3
Atlas Levels

Prob Level	L Hip R^2	R Hip R^2
1	0.90	0.86
2	0.92	0.86
3	0.92	0.87
4	0.93	0.90
5	0.93	0.92
6	0.93	0.92
7	0.93	0.92
8	0.93	0.92
9	0.94	0.91
10	0.96	0.89

The accuarcy of atlas estimation was quite robust to selection of probabilistic level. Excellent prediction was achieved for most of the levels.

Conclusions

Despite small sample sizes, these results support the findings from Part 1 that hippocampal atlas estimation has minimal impact on statistical power.

Probabilistic atlas segmentation is a reasonable and timesaving alternative to manual VOI definition.

A list of funding sources for the ADNI can be found at:
http://www.loni.ucla.edu/ADNI/Application/ADNI_License.jsp