QUANTITATIVE COMPARISON OF SPATIAL NORMALIZATION ALGORITHMS FOR 3D PET BRAIN SCANS

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Introduction

Many inter-subject automated quantitative functional neuroimaging analysis techniques require spatial registration as a preprocessing step to account for differences in orientation, size, and local anatomy. The accuracy of the registration used forms the basis for subsequent statistical comparisons and inferences. Statistical Parametric Mapping (SPM, London, UK)[1] includes a basis transform and the MIMneuro software package (MIMvista Corp., Cleveland, OH) includes a landmark-based transformation for spatially registering nuclear medicine scans.

Objectives

Here we compare the ability of the registrations provided with SPM and MIMneuro to correct for local anatomic differences across two PET tracers and ten subjects.

Methods

- T1-weighted MRI scans were obtained for 10 subjects.
- Four subjects also received ^{11}C-DTBZ PET scans and six received ^{18}FDG-PET scans
- Each PET scan was registered to a template volume using both SPM and MIMneuro.
- Two metrics were utilized to quantify registration accuracy:
  1. Correlation between the template volume and the registered subject volume
     - Correlation is inversely proportional to functional (and anatomical) variability
  2. Area under ROC curves (aROCs) for volumes of interest (VOIs).
     - VOIs were defined in template space which ranged from 100% specific to 100% sensitive for each of 13 anatomical structures as manually defined on the co-registered MRI volumes for each of the ten subjects. (see Figure 1)
     - The aROC metric is inversely proportional to anatomical variability.

Figure 1
Equations

$$\text{Sensitivity} = \frac{A \cap B}{A} \qquad \text{Specificity} = \frac{A \cap B}{B}$$

Where A = Voxels in the Gold Standard VOI and B = voxels in the tested VOI

Results

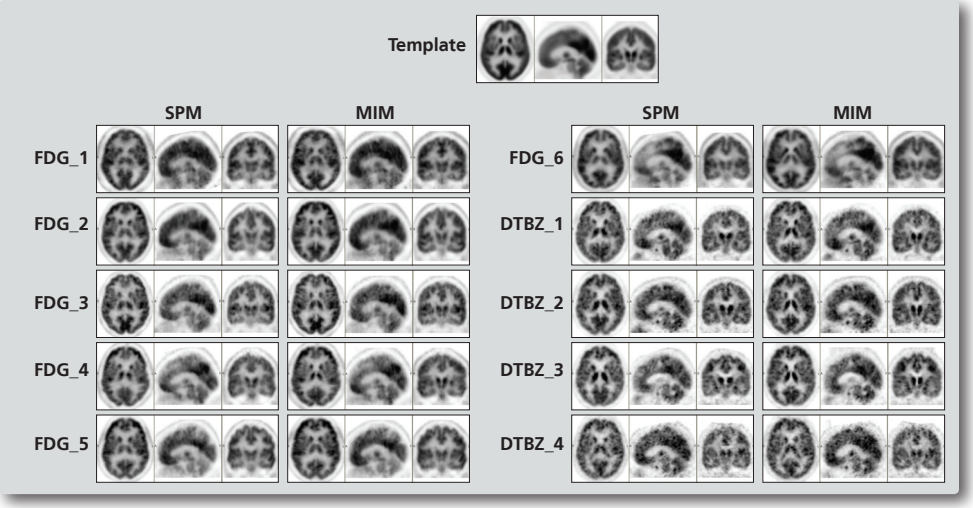
- The mean correlation was 0.869 for SPM and 0.895 for MIMneuro (see Table 1)
  - The difference was significant using the student's t-test at a p-value of 0.015.
  - The difference is also visually apparent (see Figure 2), especially in the basal ganglia.
  - In every case, the correlation after MIMneuro registration was higher than after SPM registration.
- The mean aROC was 0.860 for SPM and 0.869 for MIMneuro (see Figure 3)
  - The aROCs were very similar for most of the structures.
  - SPM showed greater consistency in registering the basis pontis and cerebellar vermis.
  - MIMneuro showed greater consistency in registering the caudate, cerebellar hemisphere and the retrosplenial area.

Table 1
Correlation Coefficients

	SPM	MIM
FDG_1	0.873	0.918
FDG_2	0.899	0.926
FDG_3	0.901	0.919
FDG_4	0.879	0.911
FDG_5	0.866	0.885
FDG_6	0.849	0.895
DTBZ_1	0.862	0.879
DTBZ_2	0.855	0.880
DTBZ_3	0.859	0.876
DTBZ_4	0.851	0.865
Mean	0.869	0.895

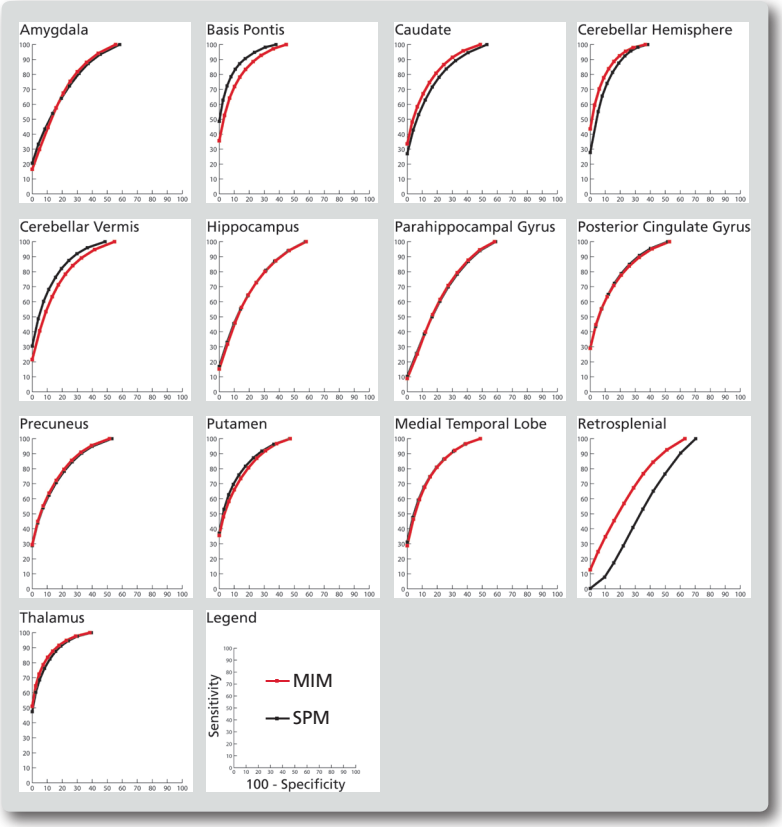
Correlations with the template volume after deformable registration. The better result with MIMneuro was significant at p = 0.015.

Figure 2
Registered PET Volumes



Results after registration to the template space. At the top is the template used, the first column are the registrations performed by MIMneuro, and the second column are the registrations performed by SPM.

Figure 3
ROC Curves



Average ROC curves for regional overlap for the 13 regions analyzed. The average sensitivity and specificity for individual subjects is shown for each region generated by taking probabilistic overlaps of single subject regions from 1/10 to 10/10 (see poster 1692).

Conclusions

- Both algorithms performed similarly at the task of reducing anatomic variation in the 13 structures analyzed.
- The significantly better correlation results for MIMneuro in comparison to SPM may indicate better performance in regions other than the 13 structures compared with the aROC metric. Additional aROC comparisons should be made to determine whether this is the case.
- Both algorithms appear adequate for spatial normalization of PET brain volumes.

References

[1]SPM. Statistical Parametric Mapping. http://www.fil.ion.ucl.ac.uk/spm/: Wellcome Department of Cognitive Neurology; 2005.

Piper JW. Quantitative comparison of spatial normalization algorithms for 3D PET brain scans. J Nucl Med. 2007;48 Suppl 2:S403.