

Neuromark PET: A fully automated ICA pipeline for positron emission tomography images

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Background

- Positron emission tomography (PET) radioligand binding may not be aligned with commonly used parcellations of neocortex [1]
- This work focuses on the beta-amyloid radioligand 18F-florbetapir (FBP)
- Independent component analysis (ICA) provides a data-driven solution to estimate high-binding regions within the brain across participants
- NeuroMark framework two steps for the GIFT software [2]:
 - GIFT developers create a template with manual interventions (this study)
 - GIFT users use a template on their subjects in a fully automated fashion
- Templates may capture a wide range of reproducible brain markers across imaging modalities [3,4]

Methods

- Subject data source: Alzheimer's Disease Neuroimaging Initiative (ADNI) [5]
 - N=300 FBP PET and T1 MRI after excluding 22 misregistrations and artifacts
 - Cognitive normal participants
 - Divided by sorting subjects by age & sex: Group A (age=76.1 yrs, SD=8.1 yrs, n=150, f=54%) and group B (age=76.0 yrs, SD=7.9 yrs, n=150, f=53%)
- Processed using PETprep_HMC [6], PetSurfer [7], PETprepMATLAB [8,9] and FreeSurfer [10], into MNI152 space, averaging four 5-min frames
 - PET voxel intensities normalized to standardized uptake value ratios (SUVR) using the cerebellar cortex as the reference region [11,12]
- GIFT ICA processing [2]:
 - Blind ICA, limited to 40 independent components (ICs), separately processed on groups A and B
- Post processing by finding correlation between paired ICs across groups A & B:
 - Max paired correlation (group A of 40 ICs, group B of 40 ICs) > 0.4 [2]
 - Paired spatial ICs correlations < 0.4 between grps A & B may not be stable enough to reproduce for future ICAs and are therefore excluded [3]
- Manual exclusion of ICs representing white matter, ventricles, cerebellar cortex, edge artifacts

Results

- Out of the 40 ICs, 28 were replicable ($p > 0.4$, Fig. 1), including 16 meaningful components and 12 IC pairs deemed by evaluator useless or artifactual
- Averaging the 16 meaningful IC pairs, between groups A & B, generating our NeuroMark PET FBP template, labeled according with domains shown in Fig. 1

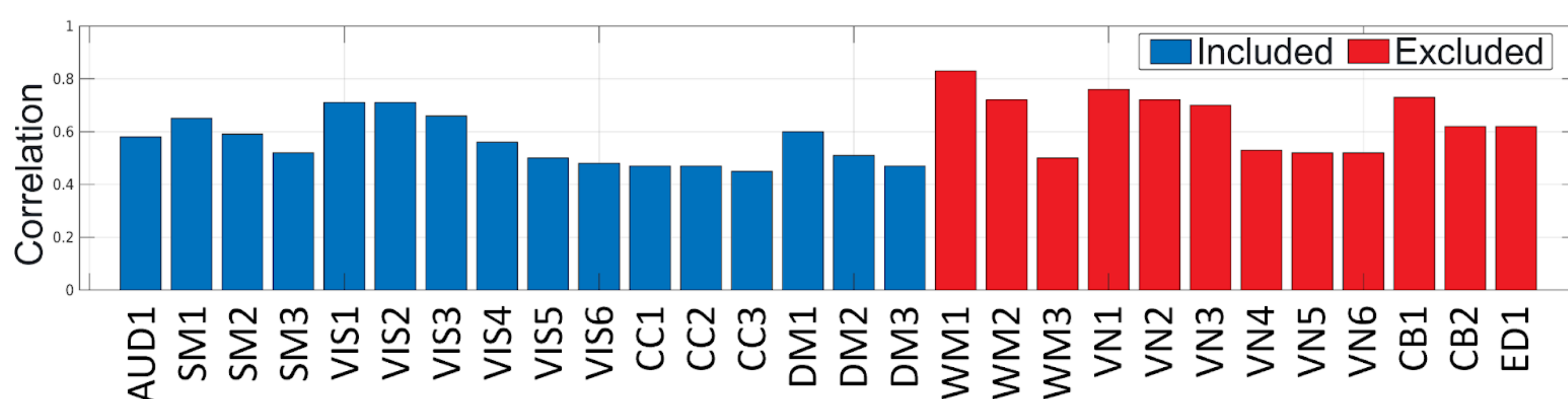


Figure 1: Each correlation shows similarity between the paired component in group A and the component in group B, having the components' NeuroMark FBP template labels on the x-axis. The components included in the NeuroMark FBP template have blue bars and are in the following domains: auditory (AUD), sensorimotor (SM), visual (VIS), cognitive-control (CC), or default mode (DM). The red bars show 12 excluded components, because they represent white matter (WM), ventricular regions (VN), cerebellar (CB) or is an edge artifact (ED).

Results

Spatial similarity (correlation in Fig. 1) was high between the two FBP groups (Fig. 2).

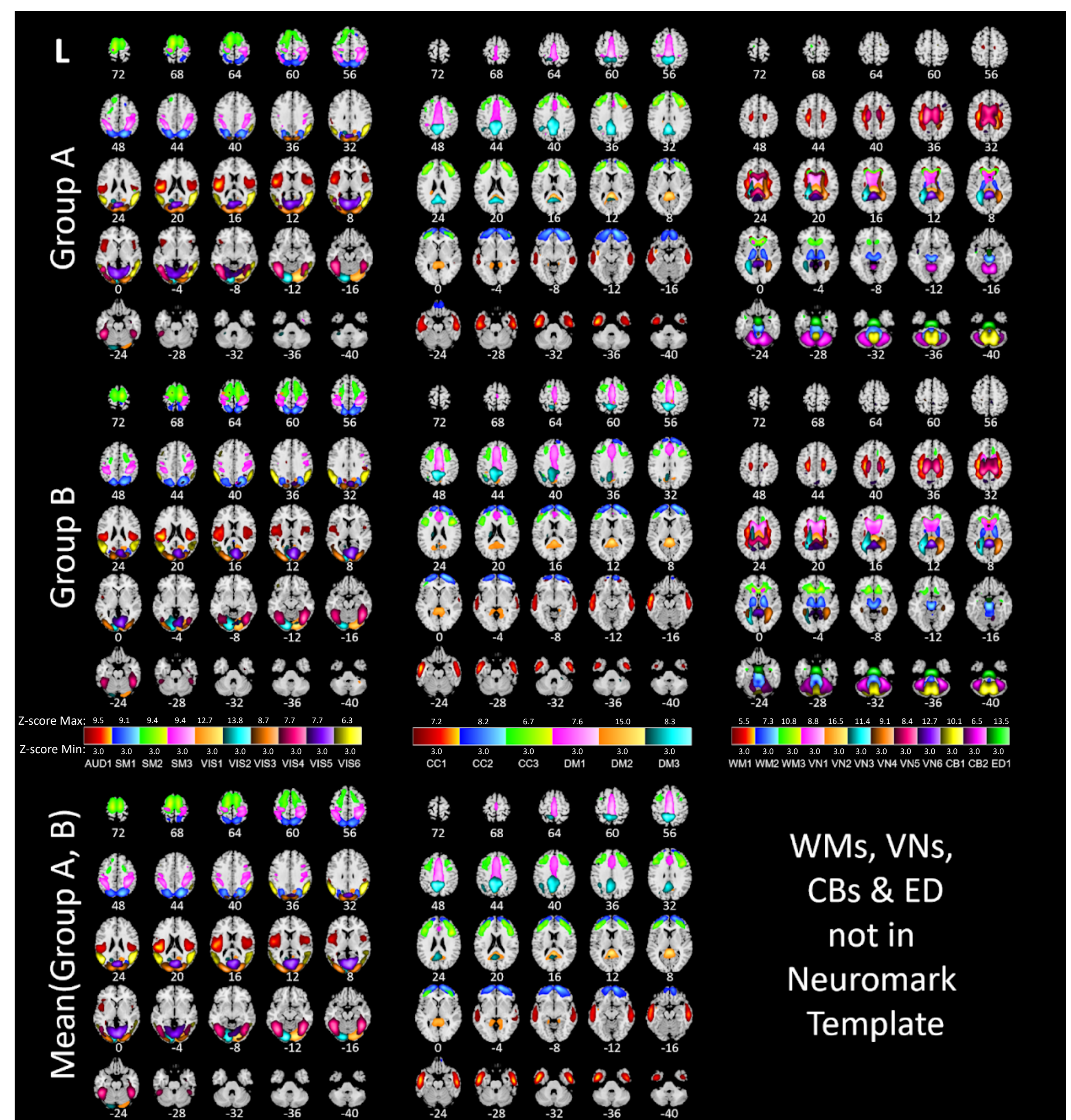


Figure 2: Independent components (ICs) from group A at the top row, and group B in the middle row and the average between group A and B in the bottom row, which is the NeuroMark FBP template. Template ICs were separated in 5 domains, having auditory (AUD), sensorimotor (SM) and visual (VIS) in the left column, cognitive-control (CC) and default mode (DM) in the middle column, and the excluded ICs, white matter (WM), ventricular (VN), cerebellar (CB) and an edge component (ED) that matched across groups are in the right column.

Conclusion

- The florbetapir PET NeuroMark template was created
 - The template can be used for a fully automated ICA pipeline implemented in the GIFT software [2]
- Using NeuroMark FBP, the uptake in the white matter and other regions are separated from the gray matter
- Since florbetapir targets beta-amyloid plaques, the ICs of this NeuroMark template may indicate where beta-amyloid varies most across a cognitive normal population
- The NeuroMark template may easily compare PET images from different populations (e.g., control vs disorder), similar with previous fMRI studies [13,14,15]

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