A Study Specific Brain Template in MNI Space for an Aged Population with Aortic Stenosis

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Introduction:

Commonly used human brain templates are usually based on healthy, adult subjects. For example, the well known Montreal Neurological Institute (MNI) template (http://www.mni.mcgill.ca/), MNI152, is the average of 152 normal T1 scans at 1mm resolution, which is ideal for spatial normalization of healthy subjects. It is a fact that brain atrophy occurs with normal aging, which can be accelerated in some disease state [1]. In this study, we aim to create a particular brain template for an NIH funded observational project of "*Stroke and Cognition in Surgical Aortic Stenosis (AS)*", in which the population was aged with mild to critical AS. The new brain template created upon this population would have great potential to improve the accuracy of spatial normalization as well as the further group analysis.

Subjects and Methods:

This study was approved by the Institutional Review Board (IRB) of the University of Pennsylvania and all participants were appropriately consented prior to participation. Ninety five (95) surgical and control subjects were recruited with the inclusion criteria of age ≥ 65 years; mild, moderate, or severe-critical AS by standard echocardiographic and/or catheterization criteria with or without concomitant coronary artery disease; male or female sex. MNI152 template is a commonly used brain template for spatial normalization, to create our study specific template in MNI space, thirty one (31) representative T1 scans were selected from the population and performed non-linear normalization with FNIRT - FMRIB Non-Linear Image Registration Tool (FNIRT), http://www.fmrib.ox.ac.uk/fsl/fnirt/index.html, via the following steps:

Step 1: T1 scans of all 31 subjects were normalized to the MNI152 template.
Step 2: Averaging these normalized images to form an aged template, calling it the MNI31_Aged template.
Step 3: The 31 T1 images (same as in step 1) were now normalized to the MNI31_Aged template.
Step 4: Repeat steps 2 and 3, until the updated template MNI31_Aged is "identical" to that in the last iteration.

This new template is approximately in MNI152 template space, but accommodates some characteristics of this particular study population, especially incorporating the increased ventricular volume of our population.

Results:

Figure 1 is the comparison of the standard MNI152 template, our study specific template (MNI31_Aged template), as well as one sample T1 slice from the population. It is clear that the new template is closer to the representative T1 slice, especially in the ventricular volume (indicated by arrows).

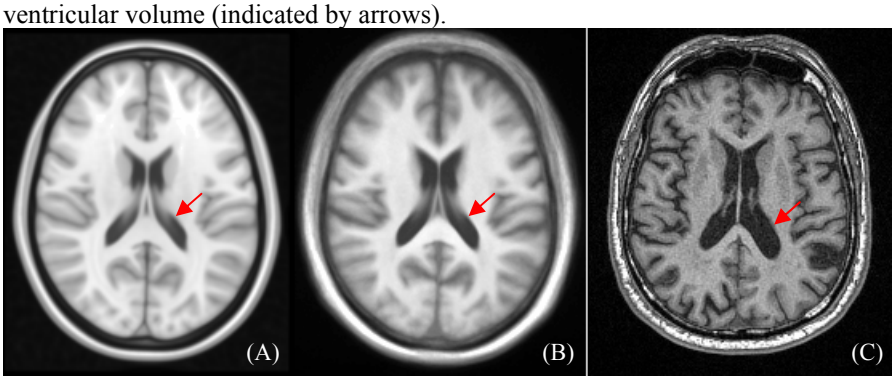

Figure 1. Comparison of (A) MNI152 template, (B) MNI31_Aged template, and (C) one representative T1 slice from a study subject.

Conclusion:

Spatial normalization of individual subjects to the standard template space eliminates differences of brain shape, size, and structure location across subjects. To minimize the amount of deformation during non-linear spatial normalization, the study specific template should be used for some particular population [2]. We created our template for an aged population with aortic stenosis, which is in MNI space and accommodates the characteristics of this population, therefore it is very useful in spatial normalization as well as the further group statistical analysis for this population.

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References: [1] Förstl, *et al*. Br J Psychiatry 1995, 167:739-746. [2] Wilke *et al*. Hum Brain Mapp 2002, 17:48–60.