

# Template Selection for fMRI Studies of Elderly Subjects

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## Introduction

Different strategies have been proposed to create a template for fMRI brain image normalization, including the use population-based templates and individual subject templates. However the template selection of a certain study may depend on the population of the study, as well as the degree of spatial deformation allowed by the registration algorithm. In this study, we evaluated the performance of an age-specific template (an elderly template, V3 [1]), the MNI Colin27 [2], and the ICBM-152 MNI template brain [3] via a block-design finger tapping fMRI task of elderly subjects normalized using Statistical Parametric Mapping [4].

## Methods

**Subjects:** Thirty-eight elderly individuals participated in this study: 15 males, 33 right-handed, age =  $71.3 \pm 7.0$  years, referred to as Group38. A subset of the 38 subjects (12 subjects, 4 males, 9 right-handed, age =  $73.6 \pm 8.4$  years referred to as Group12) with most significant age-related morphometric change was selected for additional analysis.

**Imaging:** The subjects were scanned on a Siemens Trio 3T scanner using a 12-channel head array coil. Axial T1-weighted images were acquired with 3D MP-RAGE: 176 slices,  $224 \times 256$  matrix, FOV =  $224 \times 256$  mm<sup>2</sup>, TR = 2300 ms, TE = 3.43 ms, TI = 900 ms, flip angle = 9°, slice thickness = 1mm, no gap. Five-minute finger tapping fMRI scans were performed with standard FID-EPI: 28 slices,  $128 \times 128$  matrix, FOV =  $256 \times 256$  mm<sup>2</sup>, TR = 2000ms, TE = 34m, flip angle = 90°, slice thickness = 3mm, no gap, 150 time frames, grappa = 2. Subjects were instructed to tap both index fingers at frequency of 1.3 Hz, paced by a flashing stimulus. There were 10 blocks of 30 seconds each, 5 blocks of tapping that alternated with 5 blocks of rest.

**Templates:** The age-specific template (V3) was created with T1-weighted SPGR images from 416 subjects (age =  $69 \pm 7.5$  years) acquired as part of other studies at the Pittsburgh MR Research Center. There were no subjects in common between those used in creating template in those who participated in this study. The performances of the ICBM-152 MNI template brain (average age of 23.4 years) and the smoothed MNI Colin27 template (8-mm Gaussian filter) were also compared.

**Image processing:** The functional images were co-registered (i.e., motion-corrected and registered to MP-RAGE) and then normalized to the three different templates (V3, ICBM-152 and Colin27) using the default normalization algorithm in SPM5. This registration method first segments the gray matter of each image, smooths this with an 8-mm Gaussian filter, registers to the template with an affine linear registration, and then proceeds with the nonlinear registration model. For each template, the contrast maps of all subjects (Tap>Rest, level 1 analyses) were compared to 0 for level 2 analyses (Group38 test). The resulting t-maps of the different templates (V3, ICBM-152 and Colin27) were then compared to evaluate the performance of the respective templates.

In addition to Group38 test, the 12 subjects with particularly large ventricles (i.e., prominent age-related changes) were compared, using the same method as above, to test whether the elderly template was particularly useful for the individuals with prominent age-related morphometric changes (Group12 test).

## Results

The coronal slices of the activation maps from the two sets of images are shown in Fig. 1, with the corresponding template as the underlay image. The activation map from Group38 test was thresholded at FWE  $p < 0.05$  with cluster size of 5, and the activation map from Group12 test was thresholded at  $p < 0.01$  with cluster size of 5. As expected, brain activations of finger tapping were seen in the primary and secondary motor cortices and visual areas on both side of the brain for all three templates. For quantitative comparisons of the results the volume of activation (number of voxels) and the peak T-values for regions of interest identified in the medial and lateral motor cortices are shown in Table 1.

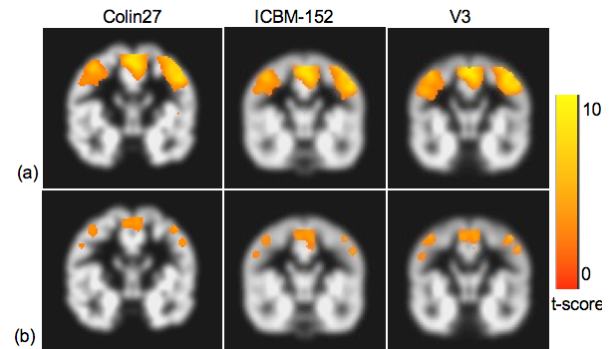
## Discussion and Conclusion

In this study we have compared performance of 3 different templates in terms of co-localization of fMRI signal in a group of elderly individuals on a finger tapping task. Due to the anatomic differences in elderly versus mid-age individuals, one might expect that fMRI analyses of elderly subjects should be done with elderly template brains rather than the mid-age standard ICBM template. For all 3 templates we found the expected functional map associated with finger tapping. The maximum t-values, location, and size of the regions were similar for all 3 templates. When we looked specifically at those elderly subjects with the most prominent ventricles (i.e., the most age-related anatomic changes) we saw a suggestion that there was a greater peak and smaller extent for the most medial motor cortex region. However, there remained little difference between the performances of the templates in the most lateral motor cortex. These results suggest the elderly template may be most beneficial for co-localization in medial region that could be more affected by their proximity to the ventricles.

## Reference

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**Fig. 1. The activation maps from finger tapping task with different templates: Colin27, ICBM-152 and V3 for Group38 test of all 38 subjects (a), and Group12 test of a subset of 12 subjects with prominent age-related changes.**

Template/Experiment	Group38 test: cluster size (peak t)		Group12 test: cluster size (peak t)	
	Medial motor	Lateral motor	Medial motor	Lateral motor
Colin27	901(9.85)	2945(12.80)	778(5.12)	1941(5.96)
ICBM-152	972(9.42)	3025(12.97)	865(5.2)	2054(6.03)
V3	935(9.97)	3093(12.72)	<b>841(6.58)</b>	1997(5.66)

**Table 1 quantitative measurement of the activation maps from different templates.**