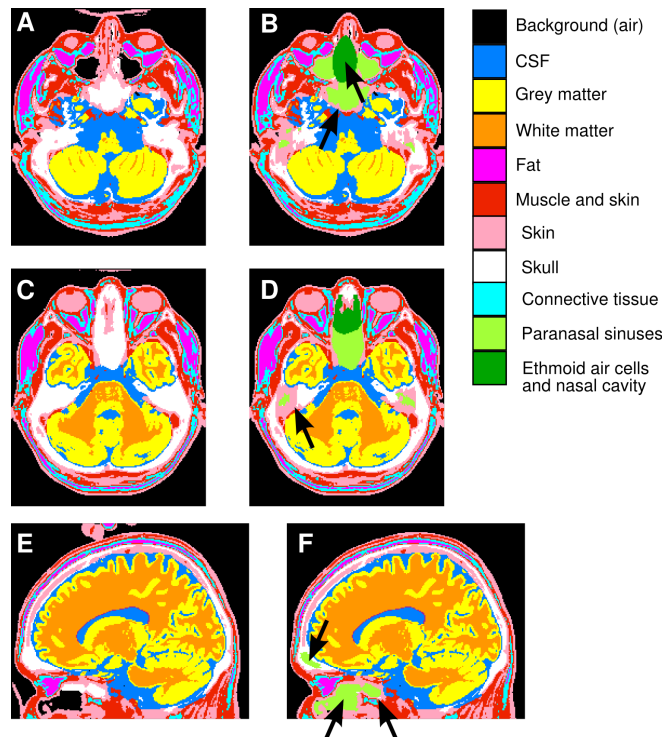
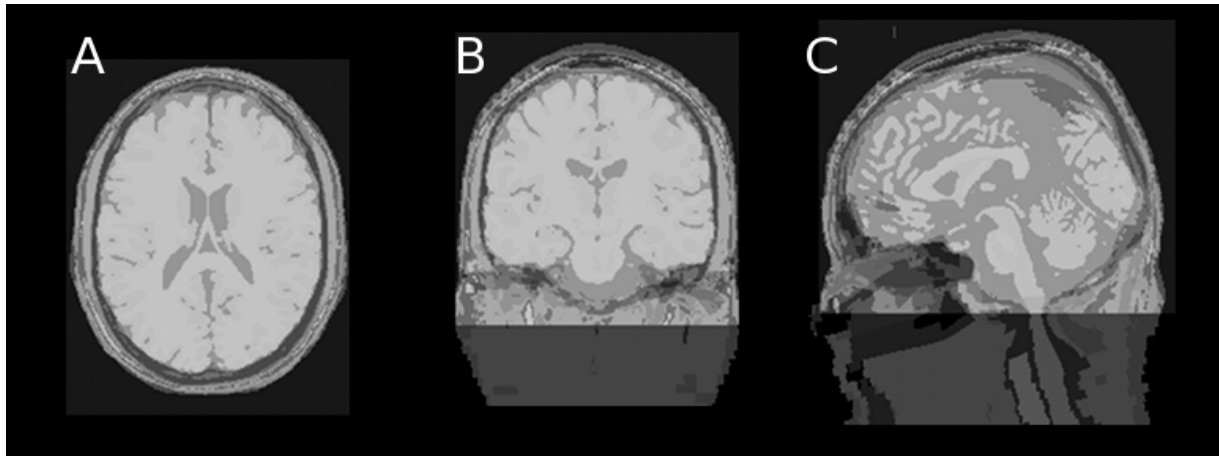


**Attenuation correction methods suitable for brain imaging with a PET/MRI scanner:  
A comparison of tissue atlas and template attenuation map approaches**

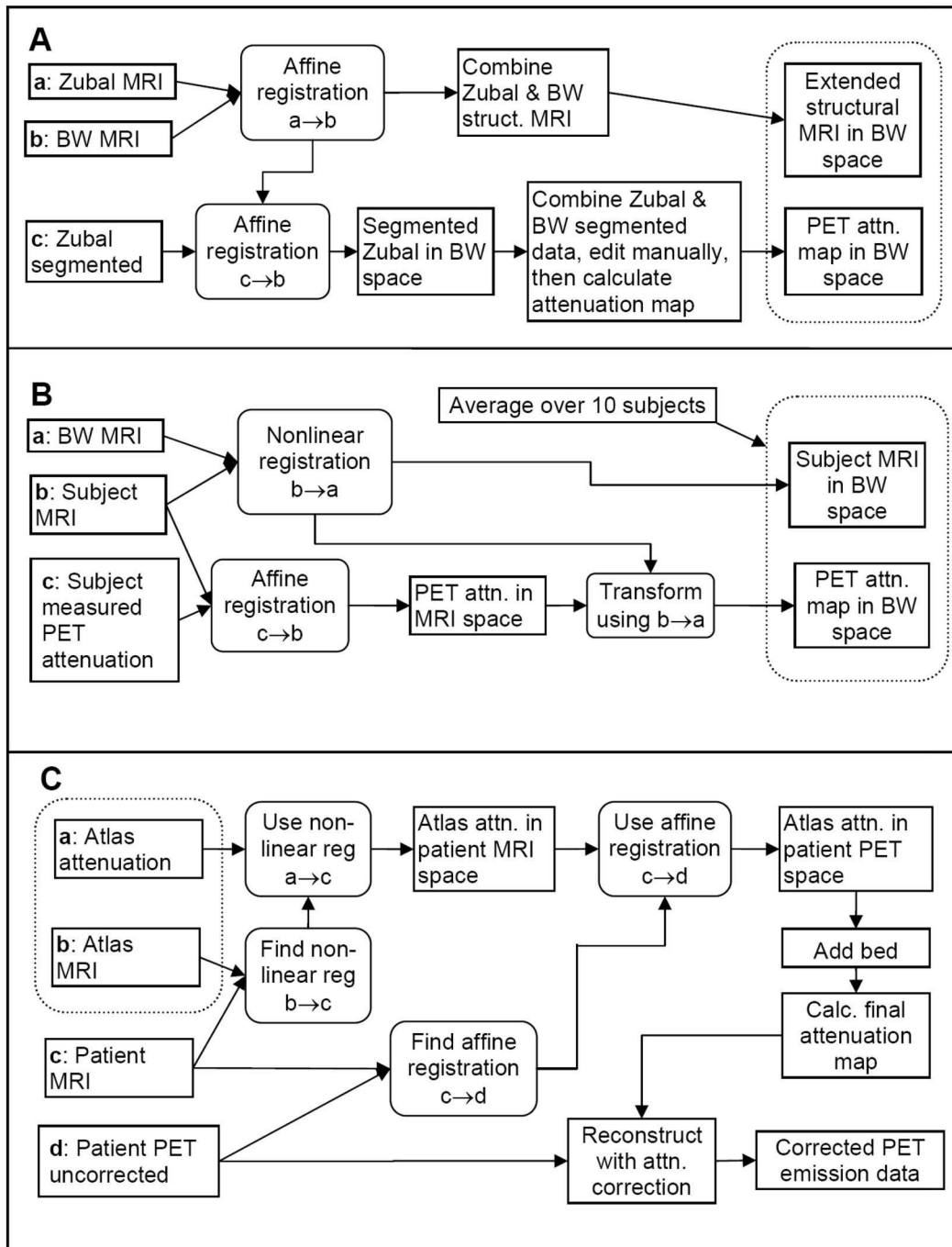
Ian B Malone, Richard E Ansorge, Guy B Williams, Peter J Nestor,  
T Adrian Carpenter, Tim D Fryer



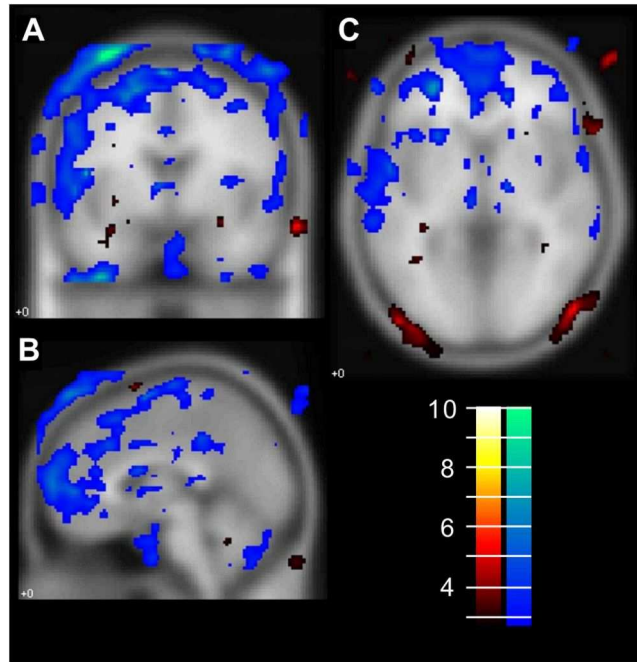
**SUPPLEMENTAL FIGURE 1.** Original BrainWeb tissue atlas (15) and modified version. Original classes: A, C and E; modified classes: B, D and F. Arrows denote the modifications: B maxillary (anterior) and sphenoidal (posterior) sinuses, ethmoid air cells and nasal cavity; D temporal bone/mastoid cells; F frontal sinus (superior), maxillary and sphenoidal sinuses (inferior). Artefacts outside the head on the original atlas (apparent on A and E) were removed from the modified atlas.



**SUPPLEMENTAL FIGURE 2.** Transverse (A), coronal (B) and sagittal (C) slices through the tissue atlas produced by combining the BrainWeb (15) and Zubal (16) phantoms. As the BrainWeb phantom only covers the superior part of the head, the Zubal phantom (co-registered to the BrainWeb phantom) is used to model the inferior portion of the head to improve the accuracy of attenuation correction in the inferior part of the brain.



**SUPPLEMENTAL FIGURE 3.** Flowcharts for joint MRI and attenuation map creation (A and B), and use for patient-specific attenuation correction (C). A: Combined BrainWeb (BW) and Zubal tissue atlas. B: Measured templates. Abbreviations: attn, attenuation; calc, calculate; reg, registration.



**SUPPLEMENTAL FIGURE 4.** Coronal (A), sagittal (B) and transverse (C) slices in MNI/ICBM152 space through t-test results for FDG images reconstructed with template attenuation correction (vtkCISG registration) compared to measured attenuation correction. Blue:  $t < 0$  test ( $p < 0.025$ ); red:  $t > 0$  test ( $p < 0.025$ ). The results were not corrected for multiple comparisons. The intensity bars denote the magnitude of the t statistic.

### SUPPLEMENTAL TABLE 1

Mean ( $\pm$  standard deviation) percentage difference in reconstructed radioactivity concentration between modelled and measured attenuation correction for 10 subjects.

Label (region of interest)	vtkCISG			Template	SPM2
	A143	A152	A172	Template	Template
Left Angular Gyrus	0.0±0.9	1.4±0.9	4.5±1.0	-1.8±0.8	-3.2±7.4
Right Angular Gyrus	-0.4±1.1	1.0±1.1	4.3±1.1	-0.6±1.1	-4.0±7.5
Left Anterior Cingulate	3.0±0.7	3.6±0.7	4.7±0.7	-1.6±0.5	-1.0±1.7
Right Anterior Cingulate	2.4±0.9	2.9±0.9	4.0±0.9	-2.0±0.7	-1.1±2.3
Left Caudate	4.5±0.8	4.9±0.8	5.8±0.8	-1.2±0.7	-1.8±2.2
Right Caudate	4.6±1.0	5.0±1.1	5.9±1.1	-1.1±0.8	-1.6±2.7
Left Cerebellar Lingual	2.2±1.1	2.6±1.1	3.6±1.1	-0.5±0.9	-2.1±3.2
Right Cerebellar Lingual	0.5±1.1	0.9±1.1	1.8±1.0	-2.0±0.8	-2.6±3.4
Left Cerebellar Tonsil	-1.2±1.4	-0.1±1.4	2.4±1.4	-1.4±1.5	0.0±5.2
Right Cerebellar Tonsil	-0.7±1.0	0.3±1.0	2.5±1.1	-1.5±1.1	0.3±3.9
Left Cingulate Gyrus	2.3±0.6	2.8±0.6	3.9±0.6	-1.3±0.6	-1.9±3.8
Right Cingulate Gyrus	1.9±0.7	2.4±0.7	3.5±0.7	-1.3±0.6	-2.4±3.4
Left Claustrum	3.9±1.1	4.3±1.1	5.4±1.1	-1.3±0.9	-0.6±2.8
Right Claustrum	4.2±0.8	4.6±0.8	5.7±0.8	-1.1±0.6	-1.0±1.9
Left Culmen	1.2±0.7	1.9±0.7	3.6±0.6	-0.2±0.6	-1.3±3.0
Right Culmen	1.2±0.7	1.9±0.7	3.4±0.8	-0.6±0.7	-1.6±2.8
Left Culmen of Vermis	4.3±1.3	4.7±1.3	5.7±1.3	-0.9±1.3	-2.9±4.5
Right Culmen of Vermis	3.6±1.3	4.0±1.3	4.9±1.3	-0.5±1.4	-0.7±4.4
Left Cuneus	-1.2±1.0	-0.3±1.0	1.8±1.0	-0.9±1.0	-3.9±6.8
Right Cuneus	-2.1±1.4	-1.2±1.4	1.0±1.5	-0.9±1.5	-4.4±7.3
Left Declive	-1.4±0.9	-0.3±0.9	2.0±1.0	-0.6±0.9	-1.8±4.7
Right Declive	-1.7±0.9	-0.7±0.9	1.7±1.0	-0.9±1.0	-2.0±4.5
Left Declive of Vermis	-0.1±1.4	0.8±1.5	2.8±1.6	-1.7±1.2	-2.5±5.9
Right Declive of Vermis	-0.2±1.2	0.7±1.2	2.7±1.3	-1.5±1.1	-2.7±4.4
Left Extra-Nuclear	4.2±0.8	4.6±0.8	5.5±0.8	-1.1±0.6	-1.5±2.2
Right Extra-Nuclear	4.5±0.8	4.9±0.8	5.9±0.8	-0.8±0.6	-1.5±2.2
Left Fastigium	1.1±0.9	1.8±0.9	3.4±0.9	1.2±1.0	-1.8±4.2
Right Fastigium	1.1±1.0	1.7±1.1	3.3±1.1	-0.5±1.0	-1.9±4.2
Left Fourth Ventricle	1.4±1.2	2.1±1.2	3.5±1.2	-0.5±1.3	-0.6±4.5
Right Fourth Ventricle	2.4±1.1	3.0±1.1	4.5±1.1	-0.1±1.1	-0.2±3.7
Left Fusiform Gyrus	-0.1±0.7	1.0±0.7	3.7±0.6	-0.5±0.7	-1.4±3.6
Right Fusiform Gyrus	0.9±0.7	2.0±0.7	4.5±0.7	0.0±0.8	-1.3±3.1
Left Inferior Frontal Gyrus	-0.8±1.1	0.3±1.1	2.7±1.2	-3.0±0.9	-0.5±3.6
Right Inferior Frontal Gyrus	-0.2±1.1	0.8±1.1	2.9±1.1	-1.8±0.9	-1.0±3.4
Left Inferior Occipital Gyrus	1.3±1.2	3.6±1.2	9.0±1.2	2.0±1.2	-2.6±7.0
Right Inferior Occipital Gyrus	0.0±2.0	2.4±2.1	7.8±2.3	0.2±2.2	-4.2±8.4
Left Inferior Parietal Lobule	-0.5±0.7	0.4±0.7	2.3±0.7	-2.1±0.6	-2.1±5.0
Right Inferior Parietal Lobule	0.0±0.9	0.9±0.9	2.7±0.9	-0.1±1.0	-2.8±4.9
Left Inferior Semi-Lunar Lobule	-5.5±1.3	-4.5±1.3	-2.4±1.2	-3.1±1.3	-0.4±4.9
Right Inferior Semi-Lunar Lobule	-5.0±1.6	-4.1±1.6	-2.0±1.5	-2.8±1.4	0.1±5.7
Left Inferior Temporal Gyrus	-1.4±0.8	0.2±0.9	3.9±1.0	-1.9±1.0	-1.6±4.2
Right Inferior Temporal Gyrus	-1.0±1.3	0.4±1.3	3.5±1.4	-1.2±1.2	-1.5±3.3
Left Insula	2.4±0.9	2.9±0.9	4.1±1.0	-1.3±0.8	-0.7±3.1
Right Insula	3.9±0.9	4.5±0.9	5.6±0.9	0.1±0.6	-0.6±2.4
Left Lateral Ventricle	5.2±1.0	5.5±1.0	6.1±0.9	-0.2±0.8	-1.5±2.3
Right Lateral Ventricle	4.8±1.0	5.1±1.0	5.8±1.0	-0.7±0.8	-1.5±2.7
Left Lentiform Nucleus	3.4±0.8	3.9±0.8	5.0±0.8	-1.1±0.5	-1.3±1.6
Right Lentiform Nucleus	4.5±0.9	5.0±0.9	6.0±0.9	-0.5±0.8	-1.4±2.6
Left Lingual Gyrus	-0.4±1.2	0.5±1.2	2.3±1.1	-0.4±1.3	-2.7±4.5
Right Lingual Gyrus	-1.6±1.5	-0.8±1.5	1.1±1.5	-1.2±1.4	-3.1±5.2
Left Medial Frontal Gyrus	-1.0±0.8	-0.3±0.8	1.2±0.8	-2.3±0.6	-1.3±2.3
Right Medial Frontal Gyrus	-1.1±0.7	-0.4±0.7	1.1±0.7	-2.0±0.6	-1.3±2.3
Left Middle Frontal Gyrus	-3.3±0.9	-2.2±0.9	0.1±0.9	-3.1±0.7	-1.0±3.7

Right Middle Frontal Gyrus	-2.7±0.8	-1.8±0.8	0.3±0.8	-1.7±0.9	-1.7±3.6
Left Middle Occipital Gyrus	-0.2±1.1	1.6±1.1	5.6±1.1	0.1±1.2	-3.6±7.9
Right Middle Occipital Gyrus	0.1±1.3	1.9±1.3	6.0±1.4	0.4±1.4	-4.2±8.2
Left Middle Temporal Gyrus	-0.7±1.0	0.5±1.0	3.2±1.1	-1.9±0.9	-1.5±3.5
Right Middle Temporal Gyrus	-0.3±1.0	0.8±1.0	3.4±1.0	-1.0±0.9	-1.8±3.6
Left Nodule	0.8±0.6	1.6±0.6	3.4±0.6	1.1±0.8	-0.4±3.4
Right Nodule	0.5±1.1	1.3±1.1	3.1±1.1	-0.7±1.1	-0.6±4.6
Left Orbital Gyrus	2.9±2.8	4.5±2.8	7.9±3.0	0.3±2.7	5.7±5.8
Right Orbital Gyrus	4.4±2.1	6.0±2.2	9.6±2.4	0.8±1.6	6.4±8.9
Left Paracentral Lobule	-1.8±0.8	-1.3±0.8	-0.2±0.7	-1.8±0.8	-2.3±4.9
Right Paracentral Lobule	-1.5±0.8	-1.0±0.8	0.2±0.8	-0.5±0.8	-2.2±4.7
Left Parahippocampa Gyrus	3.1±0.8	3.7±0.8	5.1±0.7	0.5±0.7	0.2±2.4
Right Parahippocampa Gyrus	3.1±1.0	3.7±0.9	5.1±0.9	-0.1±0.8	-0.1±3.0
Left Postcentral Gyrus	-2.9±0.7	-2.1±0.7	-0.4±0.7	-3.0±0.6	-2.5±5.5
Right Postcentral Gyrus	-2.6±0.6	-1.9±0.6	-0.4±0.6	-1.4±0.8	-3.2±5.3
Left Posterior Cingulate	2.7±0.8	3.3±0.8	4.5±0.8	-1.4±0.7	-2.9±3.4
Right Posterior Cingulate	2.2±1.1	2.8±1.1	4.0±1.1	-0.6±1.0	-3.0±4.3
Left Precentral Gyrus	-2.2±0.8	-1.4±0.9	0.6±0.9	-2.7±0.7	-1.4±4.5
Right Precentral Gyrus	-1.9±0.7	-1.1±0.7	0.6±0.7	-1.7±0.8	-2.1±4.2
Left Precuneus	0.1±0.8	0.8±0.8	2.6±0.8	-0.7±0.8	-2.7±5.4
Right Precuneus	0.2±0.8	1.0±0.8	2.7±0.8	-0.3±0.8	-3.1±5.5
Left Pyramis	-5.3±1.1	-4.3±1.1	-1.9±1.1	-2.4±1.2	-1.1±5.1
Right Pyramis	-5.4±1.5	-4.3±1.5	-2.0±1.5	-2.6±1.4	-0.6±5.9
Left Pyramis of Vermis	-6.2±1.8	-5.4±1.8	-3.5±1.9	-5.5±1.6	-1.8±5.3
Right Pyramis of Vermis	-6.1±1.9	-5.2±1.9	-3.2±1.9	-3.9±1.8	-1.9±5.3
Left Rectal Gyrus	-9.2±4.6	-8.1±4.7	-5.7±4.8	0.5±3.5	5.5±9.3
Right Rectal Gyrus	-6.1±2.6	-5.0±2.7	-2.6±2.8	2.4±2.5	6.6±10.9
Left Sub-Gyral	2.4±0.6	2.9±0.6	4.1±0.5	-1.1±0.4	-1.0±2.3
Right Sub-Gyral	3.2±0.6	3.8±0.6	5.0±0.5	0.0±0.5	-1.2±2.7
Left Subcallosal Gyrus	0.6±2.7	1.2±2.7	2.6±2.7	-1.5±0.9	-0.5±2.8
Right Subcallosal Gyrus	2.6±2.7	3.2±2.7	4.6±2.8	-0.7±1.1	-0.5±3.3
Left Superior Frontal Gyrus	-3.6±0.7	-2.5±0.7	0.0±0.8	-2.7±0.7	-1.0±2.8
Right Superior Frontal Gyrus	-2.8±0.6	-1.8±0.6	0.6±0.6	-1.9±0.6	-1.3±2.7
Left Superior Occipital Gyrus	-2.0±1.0	-0.2±1.1	4.0±1.2	-0.4±0.9	-5.4±13.7
Right Superior Occipital Gyrus	-2.0±1.4	0.0±1.4	4.8±1.5	-0.2±1.5	-6.0±12.4
Left Superior Parietal Lobule	-4.2±0.8	-3.3±0.8	-1.5±0.9	-1.1±1.0	-4.2±10.1
Right Superior Parietal Lobule	-3.9±0.7	-3.1±0.7	-1.2±0.7	-0.1±0.9	-4.4±8.6
Left Superior Temporal Gyrus	-0.2±0.8	0.7±0.8	2.8±0.8	-2.6±0.7	-0.9±2.5
Right Superior Temporal Gyrus	0.9±0.9	1.7±0.9	3.7±0.9	-0.6±0.7	-0.8±2.7
Left Supramarginal Gyrus	0.9±0.8	2.0±0.8	4.3±0.9	-1.9±0.6	-1.9±4.5
Right Supramarginal Gyrus	1.5±1.0	2.5±1.0	4.9±1.0	0.0±0.9	-2.7±4.7
Left Thalamus	5.0±0.9	5.5±0.9	6.5±0.9	-1.5±0.8	-2.4±3.1
Right Thalamus	3.1±0.6	3.6±0.6	4.6±0.7	-2.3±0.6	-2.8±1.8
Left Third Ventricle	4.3±2.2	4.7±2.2	5.7±2.2	-2.4±1.7	-2.6±5.5
Right Third Ventricle	5.1±1.3	5.6±1.3	6.6±1.3	-1.0±1.2	-0.9±3.6
Left Transverse Temporal Gyrus	0.2±1.1	1.0±1.1	2.9±1.0	-3.0±1.0	-1.3±3.7
Right Transverse Temporal Gyrus	2.3±1.1	3.1±1.1	4.7±1.1	-0.6±1.0	-1.1±2.9
Left Tuber	-3.2±0.5	-1.4±0.5	2.6±0.5	-1.1±0.5	-1.5±4.7
Right Tuber	-3.1±1.1	-1.6±1.1	2.0±1.1	-1.0±1.2	-1.1±5.2
Left Tuber of Vermis	-1.0±1.3	-0.1±1.4	2.0±1.5	-1.9±1.2	0.2±4.1
Right Tuber of Vermis	-3.6±1.6	-2.7±1.6	-0.5±1.7	-3.0±1.6	-2.5±4.4
Left Uncus	0.4±1.6	1.1±1.6	2.6±1.7	-1.3±1.3	0.5±4.7
Right Uncus	0.1±1.2	0.6±1.3	2.0±1.3	-0.5±1.0	0.5±3.3
Left Uvula	-5.0±1.0	-4.0±1.0	-1.8±1.1	-2.5±1.0	-1.5±4.8
Right Uvula	-5.0±1.3	-4.0±1.4	-1.6±1.4	-2.1±1.3	-0.8±5.6
Left Uvula of Vermis	-2.4±1.1	-1.6±1.1	0.1±1.1	-2.6±1.1	-0.5±3.9
Right Uvula of Vermis	-1.8±1.1	-1.0±1.1	0.8±1.1	-1.9±1.1	-0.7±3.9