Multi-channel (T1, T2, PD) segmentation improves grey-matter estimates for voxel-based morphometry (VBM) within and across age groups

Jason R. Taylor1, Marta Correia3, Rhodri Cusack2, Jonathan E. Peelle3, Cam-CAN4, and Richard N. Henson1

BACKGROUND

Automated segmentation of MRI images into separate tissue compartments (grey matter [GM], white matter [WM], cerebrospinal fluid [CSF], etc.) is non-trivial, and difficulties are exacerbated when sample ages span a wide range (Peelle et al., 2012; Streitburger et al., in press). Different MRI sequences have unique tissue contrast profiles and therefore provide complementary information that may be of use to the segmentation algorithm. The present study investigated whether including additional sequences (T2, PD) to supplement T1 images would improve segmentation results.

 METHODS

PARTICIPANTS

N=31 (9 female), age M=27y (21-41), Scanned twice, delay M=28d (7-42) days.

MRI ACQUISITION

Structural brain images were acquired using an 3T Siemens TimTrio MRI scanner (at the MRC Cognition and Brain Sciences Unit, Cambridge, UK) with a 32-channel head coil. Image sequences:

T1: TR=2250ms; TE=2.98ms; FA=9 degrees
T2: TR=2000ms; TE=80ms; FA=120 degrees
PD: TR=2500ms; TE=23ms; FA=110 degrees

All were whole-brain, 256x256 volumes with FOV 256x256 and voxel size 1x1x1mm. The T1 images were corrected for motion and the T1, T2, and PD images were spatially normalised into the MNI space.

AUTOMATED SEGMENTATION

Segmentation and normalisation were conducted using the SPM8 Seg toolbox, which is an update of “unified” segmentation algorithm (Ashburn & Friston, 2005). For each participant and session, images for each scan type were co-registered to the T1 image, bias-corrected (regularisation=0.01), then normalised into MNI space and segmented (tissue types: GM, WM, CSF) into three tissue probability maps. The segmentation process was performed for each scan type separately and for multi-channel combinations.

VBM ANALYSIS

GM density images were smoothed (8mm FWHM) and submitted to a VBM analysis (Ashburner & Friston, 2000) with scan types as groups in the GLM, and with an explicit mask that included only voxels for which the template GM probability was higher than 0.5. In the Cam-CAN sample, age and sex were added to the GLM. We report an analysis of age masked by a contrast of scan type (mask p<0.05 uncorrected). All maps are thresholded at p<0.05 FWE."

LABELLING CONSISTENCY

For the Re-Test sample, voxel-wise labelling consistency for each tissue class was defined as: p1 T1+T2*GM, p2 T1+PD*GM, p3 T2+PD*GM, p4 T1+T2+PD*GM. We report significant t-tests for consistency values that are greater than that for T1 alone.

ANALYSES AND RESULTS

VBM of Grey Matter Density

T1 > (T1+T2)
T1 > (T1+PD)
T1 > (T1+T2+PD)
T1 < (T1+T2)
T1 < (T1+PD)
T1 < (T1+T2+PD)

Age Effects (VBM of Grey Matter Density)

Segmentation with multiple scan types (T1+T2+PD) improves upon that with T1 alone (parallel, non-parallel, or both combined) by sharpening the distinction between GM and surrounding non-brain tissues.

Errors in GM estimates relying on a single scan type may inflate differences attributed to age.

Multi-channel segmentations including T2 and/or PD improved GM (but not WM) labelling consistency across scanning sessions.

Information gained by adding scans with complementary tissue-contrast profiles overcomes potential errors incurred at coregistration stage.

SUMMARY

REFERENCES


Streitburger et al. (in press). Impact of image acquisition on voxel-based morphometry investigations of age-related structural brain changes. Neuroimage.