Regional brain atlas for assessment of enlarged perivascular spaces

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Summary

This dataset contains a reference brain-extracted T1-weighted structural magnetic resonance image, representative of a normal brain from an individual in the first half of the 80th decade of life (70 to 75 years old), and the correspondent binary masks of the regions identified as being primary and the most eloquent sites of finding enlarged perivascular spaces, namely 1) midbrain and pons, 2) basal ganglia and 3) centrum semiovale and deep corona radiata supraventricular.

Selection of the representative brain

Sample that provided data

The Lothian Birth Cohort 1936 (LBC1936) [1] provided the sample for selecting the representative brain template. The LBC1936 is a large study of older community-dwelling adults, mostly living in the Edinburgh and Lothians area of Scotland, all of whom were born in 1936 and most of whom participated in the Scotland Mental Survey of 1947 at age 11 years. At ~70 years old, study participants (N = 1091) underwent an initial wave of cognitive and physical testing, from 2004-2007. Approximately three years later, 866 underwent a second wave of tests at mean age 72.8 years (SD = 0.7) which also involved a brain MRI scan [2]. The brain scan was undertaken by 700 individuals, but only 664 participants provided useable MRI data for the purpose of generating a cohort-specific age-relevant brain template. Of these, 664 individuals’ scans, 147 were excluded due to (one or more of) the following reasons: old infarct lesions, cysts, bad quality of the scans, aneurisms, big meningeal calcifications or any anomaly in the dura matter and/or considerable mineral deposition, leaving a total of 517 image datasets. The Multi-Centre Research Ethics Committee for Scotland (MREC/01/0/56) and Lothian Research Ethics Committee (LREC/2003/2/29) approved use of the human subjects in this study, and all participants provided written informed consent.

Selection of the representative brain
For the 517 LBC1936 Study participants considered to have the features considered normal in this population, the volumetric measurements of the parameters that are more related with the brain shape, size and degree of abnormalities, were obtained as per [2]. These parameters were: intracranial volume (ICV), cerebrospinal fluid (CSF), ventricular space, and white matter hyperintensities (WMH). For each individual, the atrophy measures were normalised by head size, and the WMHs were normalised by brain tissue volume. Then, the average and standard deviation of WMH and atrophy volumes for this cohort was calculated. These were used to calculate the Mahalanobis distance (Md) [3] and the scans were ordered in ascending Md value.

The Mahalanobis distance is a distance measure based on correlations between variables by which different patterns can be identified and analysed. It differs from the Euclidean distance in that it takes into account the correlations of the data set and is scale-invariant, having a multivariate effect size. The rationale of using Md was as follows: If each WMH and atrophy volumes are subtracted from the mean, we will know how far (or near) are these values from the one considered characteristic for this group. In modular terms and considering the variance of each parameter we will have that the normalised distance of the parameter $x$ for any subject is equal to $(\text{mean}-x)^2/\text{variance}$. If we, now, add this normalised distance calculated for each parameter (e.g. % of WMH load in brain tissue, % of CSF in the ICV…), we will have a value that indicates how much, in general, a given scan differs from the hypothetic one that will have the characteristic values of these parameters for this cohort.

Mathematically, being:

$X_1 = \% \text{ of WMH volume in Brain Tissue and } m_{x1} \text{ and } \sigma_{x1} \text{ the mean and standard deviation (respectively) of all X1 values}$

$X_2 = \% \text{ of CSF volume in ICV and } m_{x2} \text{ and } \sigma_{x2} \text{ the mean and standard deviation of all X2 values}$

$X_3 = \% \text{ of lateral right ventricle volume in ICV and } m_{x3} \text{ and } \sigma_{x3} \text{ the mean and standard deviation of all X3 values}$

$X_4 = \% \text{ of lateral left ventricle volume in ICV and } m_{x4} \text{ and } \sigma_{x4} \text{ the mean and standard deviation of all X4 values}$

$X_5 = \% \text{ of 3rd ventricle volume in ICV and } m_{x5} \text{ and } \sigma_{x5} \text{ the mean and standard deviation of all X5 values}$

$X_6 = \% \text{ of 4th ventricle volume in ICV and } m_{x6} \text{ and } \sigma_{x6} \text{ the mean and standard deviation of all X6 values}$
\[ Md^2 = \frac{(m_{X1} - X1)^2}{\sigma_{X1}^2} + \frac{(m_{X2} - X2)^2}{\sigma_{X2}^2} + \frac{(m_{X3} - X3)^2}{\sigma_{X3}^2} + \frac{(m_{X4} - X4)^2}{\sigma_{X4}^2} + \frac{(m_{X5} - X5)^2}{\sigma_{X5}^2} + \frac{(m_{X6} - X6)^2}{\sigma_{X6}^2} \]

Generalising the former equation:

\[ Md^2 = \sum_{i=1}^{n} \frac{(m_{Xi} - Xi)^2}{\sigma_{Xi}^2}, \quad (n=6) \]

The representative brain corresponded to the scan with lowest Md. The acquisition parameters of the T1-weighted sequence, and the process of extracting the volumes are described in detail in [2].

**Generation of the regional masks**

The regional masks were generated manually using the Object Extractor Tool in Analyze™ 12.0 (visit [http://analyzedirect.com/](http://analyzedirect.com/) for reference). Figure 1 shows the central slices of the T1-weighted image of the representative individual in the three main views, with the regional masks superimposed. An additional figure showing different slices in each of the three views is part of this dataset as well. All images are in Analyze 7.5 format. A document with details on this format is also part of this dataset.

If these image data are converted to NiFTI-1, care must be taken on the orientation and origin.
Figure 1. Mid-Axial, -coronal and -sagittal views of the regional atlas for assessing enlarged perivascular spaces: midbrain and pons (magenta), basal ganglia (indigo, right and green, left), and centrum semiovale and deep corona radiata supraventricular (red).

**Dataset**

In addition to this document, the present dataset contains the following files:

1) 13709_reference_brain.hdr/img : Brain-extracted T1-weighted image of the age-wise cohort-specific representative brain in Analyze 7.5 format
2) CSO_and_DCRS_axial.hdr/img : Binary mask of the centrum semiovale and deep corona radiata supraventricular region
3) LBGregion_axial.hdr/img : Binary mask of the left basal ganglia region
4) RBGregion_axial.hdr/img : Binary mask of the right basal ganglia region
5) Midbrain_and_pons_axial : Binary mask of the midbrain and pons region
6) BGandCSO_ROIs.obj : Analyze Object map of the regional atlas for assessing EPVS
7) PVS_regions_Atlas.tif/png : Figure in png and tif formats showing different slices in axial, coronal and sagittal views
8) NiftivsAnalyze_MVH_140714.pdf : Teaching material explaining the basics on MRI orientation, and the NIfTI-1 and Analyze7.5 imaging formats

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Reference List

