Lifespan quantitative MR images from 138 subjects, an open and spatially preprocessed dataset.

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Authors:

Christophe Phillips[1], Martina Callaghan[2]

Institutions:

[1]Université de Liège, Liège, Liège, [2]University College London, Wellcome Centre for Human Neuroimaging, London, London

First Author:

Christophe Phillips
Université de Liège
Liège, Liège

Co-Author:

Martina Callaghan
University College London, Wellcome Centre for Human Neuroimaging
London, London

Introduction:

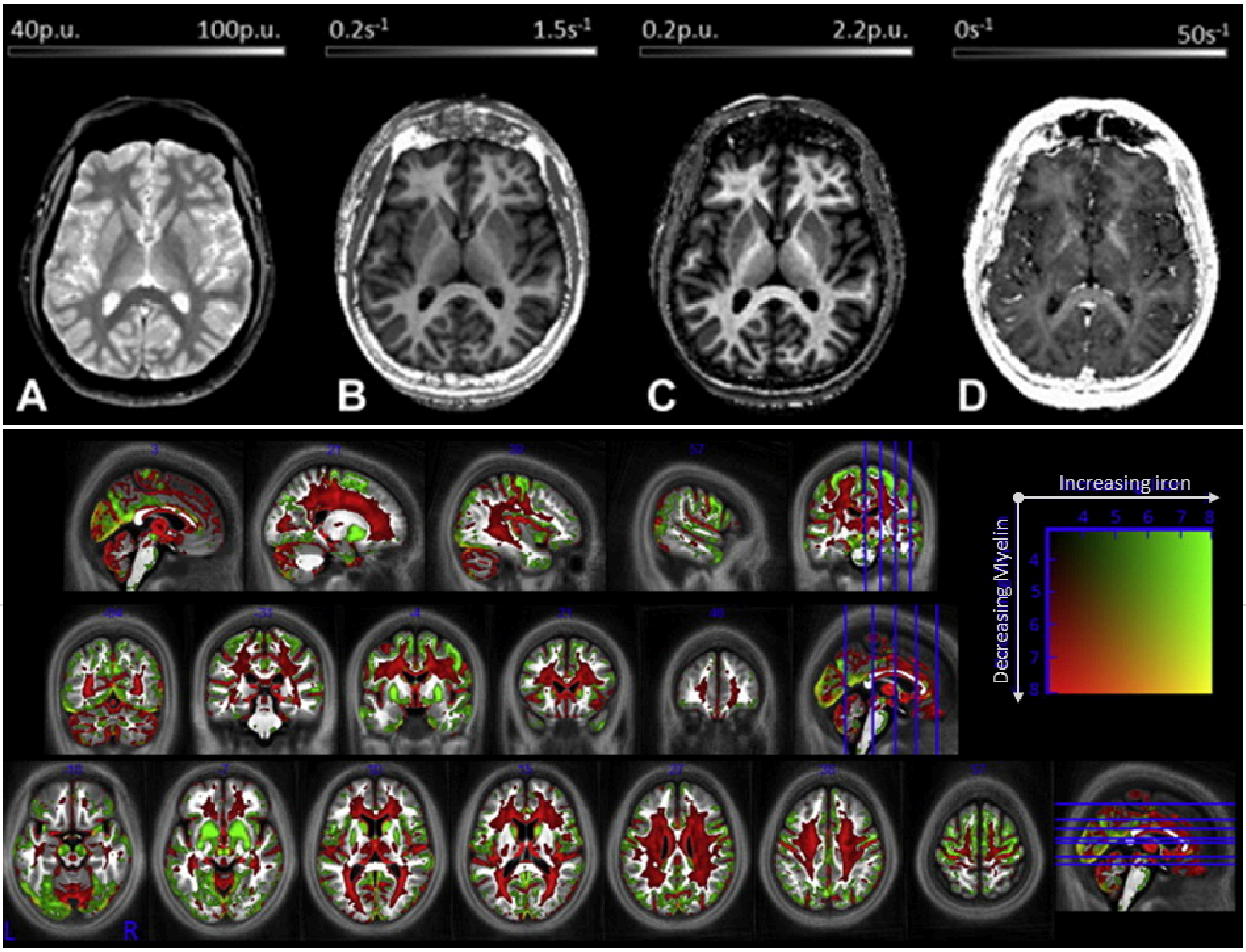
Quantitative MR Imaging (qMRI) techniques, such as the "multiparametric mapping" protocol, provide high resolution quantitative maps of brain tissue MR properties, which directly pertains to their microstructural properties, such as axon, myelin, iron and water concentration [REF1]. Such data are very relevant for the study of brain development and aging, as well as neurodegenerative diseases (Alzheimer's or Parkinson's disease, multiple sclerosis), through voxel-based quantification (VBQ) and voxel-based morphometry (VBM) analyses [REF2/3].

Our aim here is to 1/ describe the spatially pre-processed maps used by Callaghan et al. 2014 paper [REF4], and 2/ share these data according to BIDS format and its extension to structural derivative data [REF5/6].

Methods:

The dataset includes images from138 (49 males) healthy participants aged 19-75 years (mean 46.6, s.d. 21), which were acquired on 2 different 3T whole body MR systems (69 participants per scanner). The acquisition was performed by E. Anderson, M. Cappelletti, R. Chowdhury, J. Diedirchsen, T.H.B. Fitzgerald and P. Smittenaar as part of multiple cognitive neuroimaging studies performed at the WCHN (London, UK), who agreed on sharing the data.

Four quantitative MR maps (longitudinal and effective transverse relaxation rates, R1 and R2* proton density, PD, and magnetisation transfer saturation, MTsat) were reconstructed with a preliminary version of the hMRI [REF7] and VBQ [REF2] toolbox and subsequently underwent segmentation and diffeomorphic morphing to MNI space (using DARTEL). Tissue-weighted smoothing (for GM & WM separately) with a 3mm FHWM isotropic kernel was applied on the warped quantitative maps to account for residual misalignment while preserving the quantitative nature of the data, while a standard 6 mm FWHM Gaussian kernel was applied on the GM and WM modulated warped tissue maps. Moreover, group level GM and WM masks were created. Finally the age, sex, total intra-cranial volume, and scanner used, for each participants, were collected in a table. See [REF4] for full acquisition and processing details and Fig.1 for an example of quantitative maps and results from the VBQ analysis.



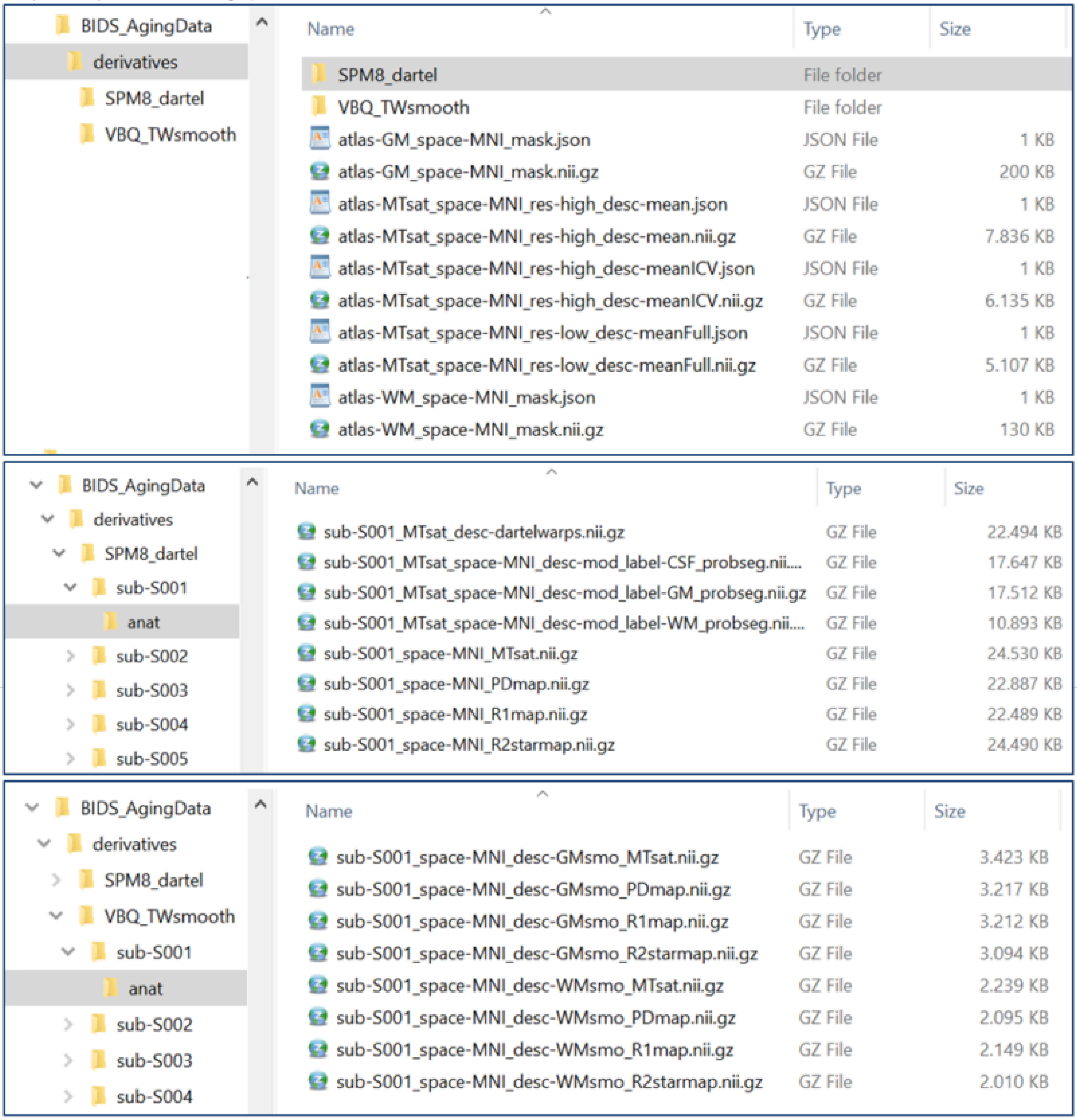
Top. Example quantitative maps of an individual volunteer: effective proton density, PD* (A); longitudinal relaxation rate, R1 (B); magnetization transfer, MT (C), and transverse relaxation rate, R2* (D).
Bottom. Whole brain pattern of aging. Myelin reductions are estimated from R1 and MT decreases while iron increases are estimated from increased R2*. This figure is thresholded at the $p<0.001$ uncorrected level for display purposes only. The *t* score for the combined effects is indicated by the color square. Adapted from Callaghan et al. 2014 (CC BY).

·Fig. 1. Example of quantitative maps and results summary from Callaghan et al. 2014 (CC BY).

Results:

The 138 subjects were randomly relabelled, from S001 to S138, and their qMRIs were brain-masked to ensure the anonymity of the participants. The spatially pre-processed data, all in MNI space, were split into 2 derivative sub-folders, plus some group level images in the main derivative folder, see Fig. 2. The 'SPM8_dartel' folder includes 8 images per participant: the 4 quantitative maps, the GM/WM/CSF tissue maps, and the deformation field. The 'VBQ_TWsmooth' folder includes 8 image per participants: the 4 quantitative maps after tissue-weighted smoothing for the GM and WM separately. The group level images are the GM and WM masks, to be used for tissue specific statistical analysis, and mean MTsat maps with 3 different masking and resolution setting, to be used for results display for example.

For easy access, data are referenced on SPM software's data sets page [https://www.fil.ion.ucl.ac.uk/spm/data/] and are actually hosted on OpenNeuro [https://openneuro.org/].



Derivative data structure and example file naming of a single subject.
Top. Main `SPM8_dartel` and `VBQ_TWsmooth` derivative folders and top-level files, with GM/WM masks and mean MTsat maps
Middle. `SPM8_dartel` derivatives with the warped quantitative maps and tissue maps, plus deformation field.
Bottom. `VBQ_TWsmooth` derivatives with the warped quantitative maps after tissue-weighted smoothing for the GM and WM separately.

·Fig. 2. Derivative data structure for the processed qMRI maps.

Conclusions:

So far only one MPM dataset, with a single subject, has been made publicly available [REF8]. Thus this unique dataset nicely complements Callaghan et al. 2014 paper [REF4], allowing anyone to reproduce the results for educational purpose. The qMRI data could also be used as a reference, thanks to their quantitative nature, for other studies. Finally the dataset will permit other researchers to experiment with qMRI data and explore new methods, such as tissue-weighted smoothing techniques, e.g. to avoid the introduction of partial volume effect, and statistical analysis approached, as in this multivariate integration preprint [REF9].

Lifespan Development:

Aging [2]

Neuroanatomy, Physiology, Metabolism and Neurotransmission:

Neuroanatomy Other

Neuroinformatics and Data Sharing:

Databasing and Data Sharing [1]

Novel Imaging Acquisition Methods:

Anatomical MRI

Keywords:

Aging
Atlasing
MRI
MRI PHYSICS
Multivariate
Open Data
STRUCTURAL MRI
White Matter
Other - quantitative MRI

[1|2]Indicates the priority used for review

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Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

Healthy subjects

Was this research conducted in the United States?

No

Were any human subjects research approved by the relevant Institutional Review Board or ethics panel? NOTE: Any human subjects studies without IRB approval will be automatically rejected.

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Please indicate which methods were used in your research:

Structural MRI
Other, Please specify - quantitative MRI

For human MRI, what field strength scanner do you use?

3.0T

Which processing packages did you use for your study?

SPM
Other, Please list - VBQ and hMRI toolbox

Provide references using APA citation style.

[REF1] Weiskopf, N. et al. (2015), 'Advances in MRI-based computational neuroanatomy: from morphometry to in-vivo histology', Curr. Opin. Neurol, 28:313-322. https://doi.org/10.1097/WCO.0000000000000222

[REF2] Draganski, B. et al. (2011), 'Regional specificity of MRI contrast parameter changes in normal ageing revealed by voxel-based quantification (VBQ)', NeuroImage, 55(4):1423–1434. https://doi.org/10.1016/j.neuroimage.2011.01.052

[REF3] Ashburner, J. & Friston, K.J. (2000),'Voxel-Based Morphometry—The Methods', NeuroImage, 11(6):805-821. https://doi.org/10.1006/nimg.2000.0582

[REF4] Callaghan, M.F. et al. (2014), 'Widespread age-related differences in the human brain microstructure revealed by quantitative magnetic resonance imaging', Neurobiology of Aging, 35:1862-1872. http://dx.doi.org/10.1016/j.neurobiolaging.2014.02.008

[REF5] Karakuzu, A. et al. (2022), 'qMRI-BIDS: An extension to the brain imaging data structure for quantitative magnetic resonance imaging data', Scientific Data, 9:517. https://doi.org/10.1038/s41597-022-01571-4

[REF6] BIDS Extension Proposals (BEPs), BEP011 and BEP038, https://bids.neuroimaging.io/get_involved.html

[REF7] Tablow, K. et al. (2019), 'hMRI – A toolbox for quantitative MRI in neuroscience and clinical research', NeuroImage 194:191-210. https://doi.org/10.1016/j.neuroimage.2019.01.029

[REF8] Callaghan, M. F.et al. (2019), 'Example dataset for the hMRI toolbox'. Data in Brief, 25:104132. https://doi.org/10.1016/j.dib.2019.104132

[REF9] Moallemian, S. et al. (2023), 'Multivariate Age-related Analysis of Variance in quantitative MRI maps: Widespread age-related differences revisited', medRXiv. https://doi.org/10.1101/2023.10.19.23297253

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