Multivariate SPM analysis of quantitative MRIs, widespread age-related differences revisited.

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Introduction:

Aging is along with alterations in the brain structure. Quantitative MR Imaging (qMRI) techniques provide in vivo neuroimaging biomarkers for myelination and iron content levels, which are sensitive to aging [1] .
Here, we investigated the association of age with gray matter myelin and iron levels in a multivariate GLM model to see if we could achieve more convergent results than the conventional multiple univariate analysis.

Methods:

We took advantage of the processed data from [1], which include 138 healthy participants aged 19-75 years (35.5% male, mean = 46.64, s.d = 21). These data acquired 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. Quantitative multiparameter maps (R1, R2*, PD, and MTsat) had been reconstructed with a preliminary version of the hMRI [2] and VBQ [3] toolbox and subsequently underwent segmentation and diffeomorphic morphing to MNI space (using DARTEL). Tissue-weighted smoothing (for GM and WM separately) with a 3mm FHWM isotropic kernel was applied to account for residual misalignment while preserving the quantitative nature of the data. Finally, group level GM and WM masks were created. For full details see [2].
In this re-analysis, we focus only on GM. The 4 resulting sets of qMRI maps were z-scored across subjects to ensure their comparability. A multiple regression analysis was performed using age, gender, total intracranial volume, and scanner as covariates to assess the correlation between the individual tissue property maps and age. Then we applied a multivariate GLM analysis using the MSPM toolbox [4] and assessed the relation between all maps combined and age, in a single inference.

Results:

The individual GM analyses on R2*, PD, MTsat, and R1 maps concurs with those in [1]. The statistical parametric maps of regions that are significantly (p<.05 FWE corr.) correlated with age for different maps are illustrated in upper part of Fig. 1. To reduce the potential false positive rate, we also checked the maps with Bonferroni threshold for 4 maps p<0.0125 FWE corr., which resulted in more conservative clusters (see the statistical summary table in Fig. 2). The table shows the number of clusters, their size range, and the number of significant voxels for each of the 4 individual SPMs, the union of their thresholded SPMs, and the MSPM results.
The multivariate GLM results illustrate bidirectional correlation for all modalities and age (p<0.05 FWE corr.), bilaterally in caudate, putamen, insula, cerebellum, lingual gyri, hippocampus, olfactory bulb (see lower part Fig. 1). Comparing the significant results from individual SPMs and MSPM shows that the number of significant voxels in the multivariate model is higher than common significant voxels in 4 individual SPMs with both FWE and Bonferroni corrections.

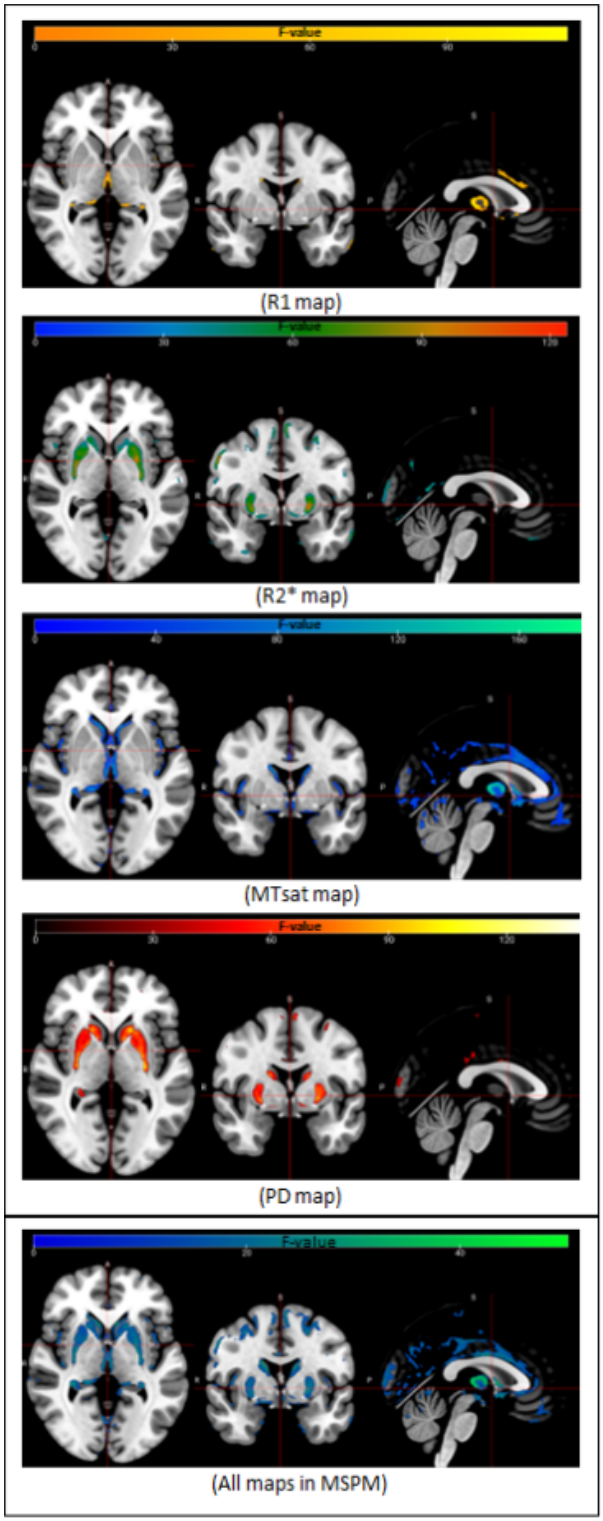

Fig. 1. Statistical parametric maps of regions where different tissue property maps significantly correlate with age (p<0.05 FWE corrected). The upper part: SPMs for different maps, the lower part: MSPM for all maps

Fig. 2. Summary table for significant voxels in SPMs and MSPM. "United" rows show the union of significant voxels in SPMs for all modalities.

		#clusters	Cluster size	#voxels
SPMs p<0.05 FWE corrected	MTsat	284	1-42251	62334
	PD	271	1-7001	28563
	R1	181	1-1336	9078
	R2*	329	1-6416	44262
	United			115957
SPMs p<0.0125 FWE corrected	MTsat	265	1-16445	50041
	PD	212	1-6671	22168
	R1	142	1-670	6276
	R2*	256	1-5919	31993
	United			90323
MSPM p<0.05 FEW corrected	All maps together in multivariate GLM	564	1-130197	154098

Conclusions:

To our knowledge, this is the first attempt to investigate multiple tissue probability maps in a multivariate GLM model in aging. The multivariate approach taken in MSPM accounts for different concurrent variations in all tissue probability maps, allowing us to look for correlations in a much more principled manner.

Lifespan Development:

Aging [2]

Modeling and Analysis Methods:

Multivariate Approaches [1]

Keywords:

MRI
Multivariate
Myelin
Other - quantitative MRI

[1|2]Indicates the priority used for review

Abstract Information

My abstract is being submitted as a Software Demonstration.

No

Please indicate below if your study was a "resting state" or "task-activation" study.

Other

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

Healthy subjects

Was 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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Not applicable

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 - MSPM

Provide references using author date format

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