Towards probabilistic atlases of the T1/T2 relaxation times from the CONNECT/ARCHI database

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Purpose The ARCHI Database [1] is a large human brain MRI database (79 healthy subjects) acquired under the framework the European CONNECT project which aims at inferring the connectome atlas of the human brain from functional and anatomical MRI data at 3T. Among the data, T1, T2 and relaxometry dataset have been acquired for all the subjects. To our knowledge, there does not exist any atlas of the relaxation times. This work is therefore focused on the construction of two probabilistic atlases of the quantitative T1 and T2 parameters of the human brain from the CONNECT/ARCHI database. We combined these atlases with the fiber density maps of the major white matter bundles we extracted from the diffusion data of the same subjects to compute the mean T1/T2 for each bundle.

Methods Data were collected on a population of 79 healthy young subjects (CONNECT/ARCHI database), under the framework of the European connectome project (CONNECT), on a Tim Trio 3T MRI system with a 12-channel head coil (Siemens, Erlangen), and the MRI protocol included the acquisition of two datasets : 1) *a relaxometry T1 dataset*: SE-EPI-single-shot / Fov=220mm ; TH=1.7mm ; 70 slices ; TE/TR=30ms/20.6s ; 128x128 ; GRAPPA2 ; PF=5/8 ; RBW=1502Hz/Pixel ; 10 TI between 300ms-3000ms ; 2) *a relaxometry T2 dataset* : GE-EPI-single-shot / Fov=220mm ; TH=1.7mm ; 70 slices ; TR=23.2s ; 128x128 ; GRAPPA2 ;PF=6/8 ; RBW=1502Hz/Pixel ; 10 TE between 30ms-200ms

The data have been corrected for susceptibility and the T1/T2 maps of each subject have been computed by fitting the following two equations to the T1 and T2 datasets, respectively: $S=\rho*(1-2*\exp(-TI/T1))$ (T1 relaxometry) ; $S= \rho*\exp(-TE/T2)$ (T2 relaxometry). A Levenberg-Marquardt algorithm was used to obtain the optimum parameters at the voxel level and we took care to adequately choose the initial parameters to take account of the high sensitivity of the algorithm to its initialization. We initialized T1/T2 close to known values of the literature at 3T: T1=1000ms, T2=90ms. All the subjects were coregistered using the diffeomorphic tensor-based technique provided in DTI-TK [2] using the HARDI data included in ARCHI database. We used the IXI template [3] to define a common frame for all the subjects. The individual T1 and T2 quantitative maps were then transformed to this frame in order to create a novel relaxometry atlas. We finally used this atlas in conjunction with the probabilistic maps of the different bundles described in [1] to compute the statistics of their T1 and T2 relaxation time. The probabilistic fiber density maps naturally define the regions of interest corresponding to the various WM fibre bundles.

Results & Discussion Fig 1 shows the T1/T2 quantitative maps for one axial slice from the atlases. The maps clearly depict a good contrast between the various brain structures. Fig 2 shows the bundle atlas we employed to perform the automatic bundle segmentation and described in [4]. Table 1 summarizes the statistics (mean and standard deviation) of T1 and T2 obtained for a series of well-known WM bundles of interest. In future work, we will take into account a priori anatomical information to correct partial volume effect that may affect the mean T1/T2 values for small bundles. No T1/T2 atlases have been provided to the community for now with such a large population. Combining these relaxometry data with the diffusion data of this database could be of a great interest to microstructure studies. We showed here one of the potential application, namely the possibility to compute the average T1/T2 relaxation times for all the WM bundles.

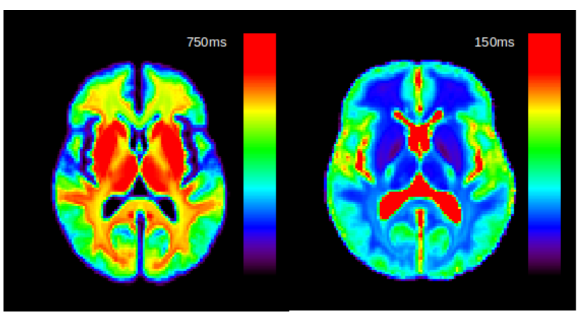

Fig1 a. T1 Relaxometry atlas b. T2 Relaxometry atlas

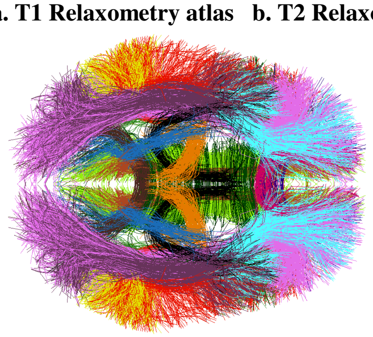

Fig2. Bundle atlas

Bundles	T1 (ms)	T2 (ms)
Arcuate Anterior Left	596.257+-111.79	77.2202+-13.2459
Arcuate Anterior Right	598.477+-104.491	77.0886+-12.7391
Arcuate Right	644.837+-60.6078	72.2389+-7.63583
Arcuate Left	621.403+-81.7891	71.9173+-5.90902
Arcuate Posterior Left	523.559+-127.653	80.114+-10.8715
Arcuate Posterior Right	545.2+-110.9	78.0578+-8.85713
Cingulum Long Right	591.541+-115.351	70.4856+-6.82386
Cingulum Long Left	594.832+-109.505	70.3922+-6.74432
Cingulum Short Left	537.935+-137.194	75.2391+-10.5083
Cingulum Short Right	539.14+-138.412	74.2926+-10.0084
Cingulum Temporal Right	558.603+-168.904	88.8107+-29.2417
Cingulum Temporal Left	580.539+-146.432	86.3448+-24.2756
CorpusCallosum Splenium	612.022+-109.48	95.957+-53.798
CorpusCallosum Genu	534.173+-140.854	95.4439+-56.9274
CorpusCallosum Rostrum	539.599+-111.854	83.6835+-44.3861
CorpusCallosum Body	575.399+-128.337	75.7437+-32.5826
CorticoSpinalTract Left	653.052+-111.093	80.0061+-22.4178
CorticoSpinalTract Right	651.087+-113.588	81.6412+-24.2388
Fornix Left	470.705+-200.348	149.393+-101.835
Fornix Right	467.513+-209.468	148.871+-105.42
InferiorFrontoOccipital Left	652.348+-67.6198	74.698+-9.69363
InferiorFrontoOccipital Right	657.95+-64.387	75.6785+-11.7558
InferiorLongitudinal Left	607.984+-92.9507	71.8923+-18.2364
InferiorLongitudinal Right	622.621+-87.0801	73.307+-17.3845
Uncinate Right	598.165+-151.511	71.5941+-9.56687
Uncinate Left	613.999+-138.806	71.8141+-10.1184

Table 1. Mean T1 and T2 and standard deviation values for well-known bundles

References [1] B. Schmitt et al, ESMRMB 2012; [2] H. Zhang et al, MedIA 2006 10(5):764-85;[3] H. Zhang, WBIR 2010 [4] P. Guevara et al, 2012, NeuroImage 61: 1083–1099