A bi-compartmental model to resolve R2* relaxometry

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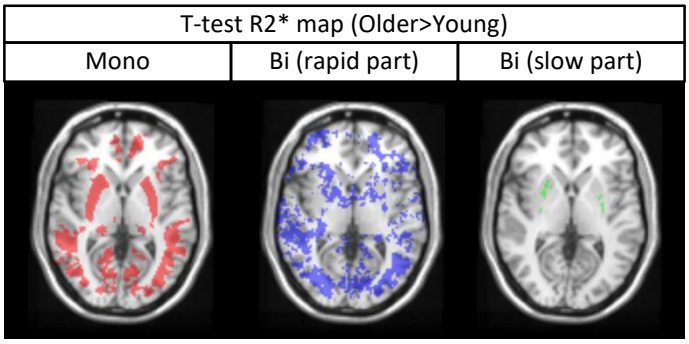
PURPOSE/INTRODUCTION: The quantification of intracerebral iron content *in vivo* is an objective of modern imaging. Iron quantification is used to study pathophysiological mechanisms of neurodegenerative diseases [1]. For this aim, one method used to quantify iron content is the R2* relaxometry [2]. This approach extracts one parameter, the relaxation rate (R2*) for each voxel. The calculation of R2* is mainly conducted by fitting a mono-exponential signal decay curve, which assume a single tissue in the voxel (mono-compartmental). However, the tissue within a large voxel can be heterogeneous (e.g. iron, myelin). Our work aims to develop a fitting of a bi-exponential curve to address a bi-compartmental resolution of R2* relaxometry. We tested this approach to measure iron-content increase related to normal aging [2].

SUBJECTS AND METHODS: First we conducted a simulation study to obtain threshold for the bi-exponential method that describes when a voxel contain two compartments. Second, phantom study, realised on 3D print, to check a bi-exponential equation and the threshold. The phantom contains three tubes with three different fillings. We alternate between white matter extract from brain sheep, copper sulphate ($CuSO_4$) and iron(II) oxide to fill tubes. Multi echo gradient and multi echo spin echo were acquired, to calculate R2 and R2* maps. We analysed images (3D T1-FFE, TE: 6-12-20-30-40-55 ms) from 40 young subjects (mean =29±6 years) and 37 older subjects (mean = 68±6 years). Image processing was performed using ANTs and FSL, and image filtering for noise reduction has been applied with NESMA filter [3].

RESULTS: The simulation study give us a threshold to determine when a voxel was bi-compartments based on the SNR of image. The phantom study confirmed that it is possible to evaluate the number of components from R2 relaxometry: one component from homogeneous (only iron) tube and two compartments from heterogeneous (white matter and iron).

The figure showed significant R2* voxels higher in older subjects group than in younger one using t-test. Result showed that we can distinguish two age-related spatial patterns using with bi-compartmental method. The difference of rapid component concerns mainly white matter region. The difference of slow component concerns mainly the putamen.



DISCUSSION/CONCLUSION: Our results showed the feasibility to calculate bi-compartment maps from R2* relaxometry. Our age-reated results can be interpreted by a better sensitivity to myelin for the rapid component and a better sensitivity to iron-content for the slow component. Bi-R2* relaxometry could be used to better distinguish the respective contribution of iron and myelin.

REFERENCES: [1] Altamura et Muckenthaler, 2009. JAD [2] Péran & al, 2007. JMRI [3] Bouhrara & al, 2019, MRI