AGE-DEPENDENT CHANGES IN WHITE-MATTER AND GRAY MATTER BRAIN T1RHO VALUES

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Purpose

To determine if quantitative $T_{1\rho}$ MRI is sensitive to the processes of normal aging in the human brain, and to provide normative values of $T_{1\rho}$ in white matter (WM) and cortical gray matter (GM). Since $T_{1\rho}$ is thought to be sensitive to the complex macromolecular content of tissue, it may have important applications to neurodegenerative disease.

Methods

41 subjects (23 males, 18 females) aged 18-76 with no history of neurological disease were recruited in this IRB-approved study. Data was acquired using a Philips 3T Achieva TX scanner and an 8-channel head coil. Whole-brain $T_{1\rho}$-weighted images were acquired using a fluid attenuated variable flip angle 3D turbo spin echo technique (TE/TR/TI=20/4800/1650ms, matrix size 140×140×100, spatial resolution 1.8×1.8×1.8mm^3). Images were acquired with a spin lock frequency of 500Hz and spin lock durations of 0, 20, 40, 60, 80 and 100ms. Each $T_{1\rho}$ map was calculated based on a single exponential fit to the coregistered $T_{1\rho}$-weighted images. The $T_{1\rho}$ map was then itself coregistered to a T_1-weighted anatomical scan. Using unified segmentation[1] (SPM8) of the T_1-weighted image, the $T_{1\rho}$ maps were segmented into WM and GM and spatially normalized to MNI space. Major WM tracts were defined using the JHU atlas[2], while cortical GM and juxtacortical WM were defined by an intersection of the Harvard-Oxford cortical atlas (dilated by 5mm) with the subject-specific GM and WM masks respectively.

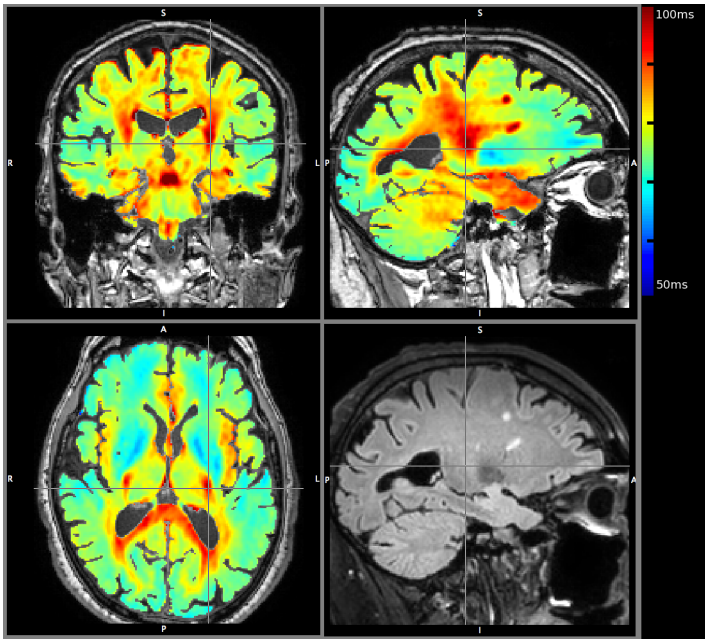

Figure 1. $T_{1\rho}$ map and T2-FLAIR from a 75 year old male.

Results

The new technique produced high SNR whole-brain $T_{1\rho}$ maps with an acceptable scan duration of ~14 minutes (Figure 1). The maps demonstrate excellent WM-GM contrast, with major WM tracts such as the corticospinal tract (left=86.1±2.1ms, right=85.6±1.9ms, mean±std dev) and fornix major (84.4±2.5ms) showing high $T_{1\rho}$ values in all subjects compared to other tracts and juxtacortical WM (75.6±1.4ms). Cortical GM showed a significant negative correlation between $T_{1\rho}$ and age (r=−0.599, p<0.001), major WM tracts demostrated a positive correlation (r=0.527, p<0.001), while juxtacortical WM showed no significant correlation with age (r=0.035, p=0.830) (see Figure 2)

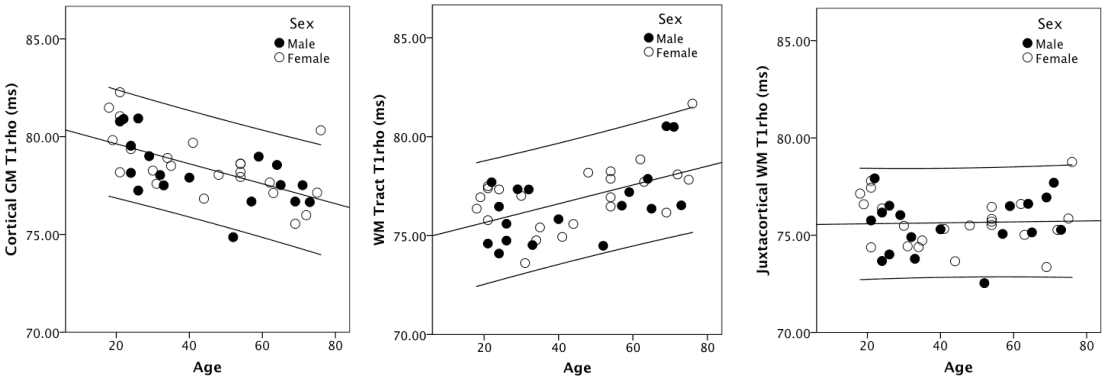

Figure 2. $T_{1\rho}$ variation with age in cortical GM, major WM tracts and juxtacortical WM. Lines represent 95% CI.

Discussion and Conclusions

Since $T_{1\rho}$ is sensitive to macromolecular content of tissue, it may provide an important biomarker of changes associated with many neurodegenerative diseases, including Alzheimer's disease[4] and multiple sclerosis. We have demonstrated that $T_{1\rho}$ is sensitive to the processes of normal aging, suggesting that it may also be sensitive to pathologic changes. This is the first systematic study of the variation of $T_{1\rho}$ over adulthood using a novel approach which provides whole-brain coverage and excellent fluid suppression and provides important normative data for future studies of disease pathology.

References

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