The Age and Gender Dependence of Total Transverse Relaxation Rate in Normal Human Brain at 3 T

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Introduction

The utilizations of MRI and *in vivo* MRS at 3 T for clinical examinations and research have seen a steady increase. The transverse relaxation plays an important role in human brain MRI. Total transverse relaxation rate R_2* ($1/T_2$*) has been shown to be useful in the measurement of tissue iron content. In this study, by using a high-resolution 3D R_2* mapping method, multi gradient-echo slice excitation profile imaging (mGESEPI) [1], we systemically characterized anatomical distribution of the R_2* variability with age and gender in the human brain at 3 T.

Methods

Human Subjects

Thirty-nine healthy normal volunteers (22 males and 17 females, 24.5 ± 10.8 years of age, range 9 to 50 years) participated in the study. There was no significant age distribution difference between the two gender groups ($p = .45$). Participants had no history of neurologic or psychiatric diseases. All subjects and parents of the subjects under 18 years of age gave informed written consent prior to participation.

MRI Protocol

The mGESEPI method [1] was used to scan the brain on a Bruker MedSpec S300 3 T system with a TEM head coil for RF transmission and reception. Imaging parameters were: TR / TE / FA = 360 ms / 8 ms / 50º, bandwidth = 100 kHz, 12 echoes, 5 10-mm-thick axial slabs centered at the level of hippocampus with no gap between slabs, FOV = 25 × 25 × 1 cm^3, matrix = 256 × 192 × 16.

Data Processing and Analysis

The R_2* maps were generated using linear regression with a home-developed software for quantitative MRI written with Interactive Data Language. The R_2* maps from all the subjects were normalized to the Montreal Neurological Institute brain template [2] using SPM2 [3]. The resultant resolution of the R_2* map was 1 × 1 × 2.5 mm^3. Both voxel-based and region of interest-based statistical analyses were performed.

Results

The voxel-based analysis showed an evident age dependence of R_2* in the basal ganglia, amygdala, thalamus, and red nucleus (Figure 1). Regression analyses revealed that an increase of R_2* followed a similar logarithmic trend in most of these structures, i.e., a rapid increase of R_2* from 9 to 20 yeas of age followed by a slower rate of increase from age 20 to 30 years. The rate of increase was further reduced after 30 years of age. Figure 2 shows R_2* of the left amygdala as a function of age. No significant difference was observed between the two gender groups (Ancova, $T < 3.35$) with age as a covariate. Table 1 shows the heterogeneity of R_2* distribution in some selected brain structures of 30 to 50 years old healthy normal human. The magnitude of R_2* change versus age varied with brain structures. No significant lateralization effect was observed (paired t-test, $p > .25$).

Discussion & Conclusion

The age dependence of R_2* in the brain exhibited a complex distribution with respect to brain anatomy. The R_2*-age regression followed a pattern similar to the one of brain tissue iron concentration obtained by a previous postmortem study [4]. This indicates that tissue iron plays an important role in the changes of brain R_2* during normal development and aging and, conversely, R_2* mapping has the sensitivity in the detection of age-related iron changes in the brain *in vivo*. There was no significant gender difference on R_2* distribution and its change with age.

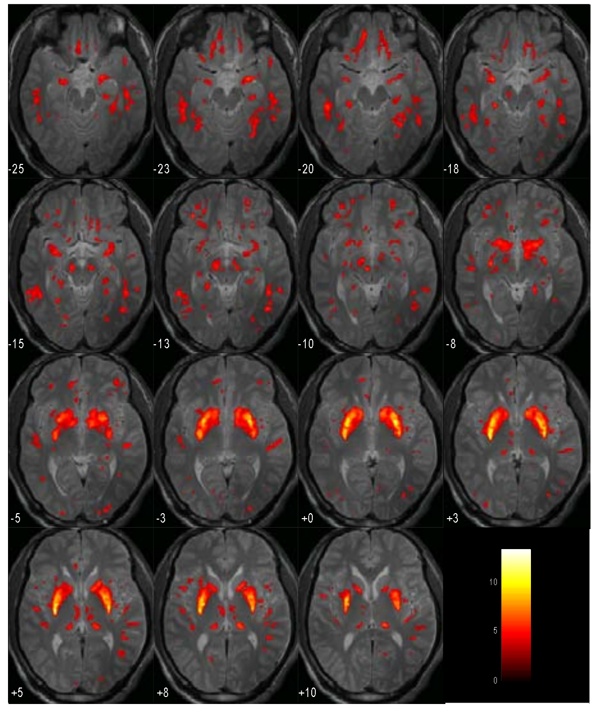

Figure 1. The anatomic structures showing positive linear correlations between R_2* and age (simple regression, uncorrected, $p < .001$, extended threshold = 6). The brighter the color, the higher the correlation coefficient.

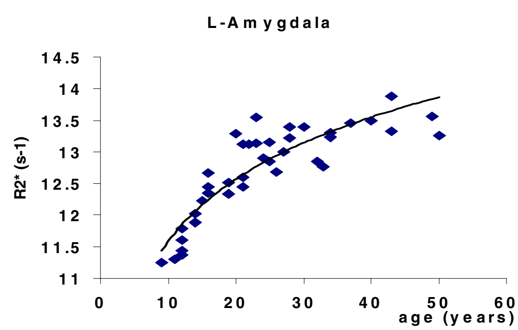

Figure 2. The age dependence of R_2* at left amygdala from 39 healthy normal subjects ($R^2 = .79$).

	Amygdala	Putamen	Ant Thalamus	Pos Thalamus
Left	13.32/.31	14.28/.51	12.42/.39	12.75/.58
Right	13.30/.34	14.24/.49	12.43/.32	12.89/.54

Table 1. R_2* (mean/std, s^{-1}) of selected brain structures (age 30 to 50 years). Ant, anterior; Pos, posterior.

References

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