# Secular-T2 MRI: quantitative MRI of the cerebrum and cerebellum in 24 subjects

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**Purpose:** To study comparatively the whole-brain distributions of $T_1$, $T_2$, and secular-$T_2$ ($T2^{(sec)}$) of 24 adult human subjects over a wide age range. An additional purpose was to investigate potential spectral differences between the four main brain compartments: left and right cerebral and cerebellar hemispheres.

**Theory:** Generating self co-registered and nearly-simultaneous $T_1$ and $T_2$ maps could be useful for the assessment of disease because these two tissue parameters contain different biophysical information that are largely independent of each other. However, $T_1$ information and $T_2$ information are not fully independent of each other because all spin-lattice interactions that cause $T_1$ recovery also contribute to $T_2$ decay. The difference between the $T_1$ and $T_2$ relaxation rates represents the pure spin-spin interactions and is known as the secular relaxation rate. The associated secular-$T_2$ relaxation time (**Ref**. 1, 2) is given by: $T_2^{(sec)} = T_2/(1 - T_2/2\,T_1)$.

**Methods:** Mixed turbo spin echo (mixed-TSE) multislice 2D pulse sequence (**Fig 1**) was used in the axial plane covering the entire head with null interslice gap: 0.94 x 0.94 x 3mm$^3$ voxel size with a 1.5 T superconducting MR imaging system (NT-Intera Philips Medical Systems, N.A.). Mixed-TSE combines the principles of T1-weighting by inversion recovery and T2-weighting by dual-turbo spin echo sampling into a single mixed MRI acquisition. Self-coregistered T1 and T2 maps were generated and used as input for a $T2^{(sec)}$ algorithm. Over a four months period, 24 subjects (average age: 47 years (range: 23-87), 14 females and 10 males) were enrolled for this study: two volunteers and 22 patients who underwent MRI for various clinical indications. Subjects were consented following INH HIPAA guideline and protocol for both volunteer and patients approved by the internal review board of our institution. Left and right cerebral and cerebellar hemispheres were segmented using a dual-space clustering algorithm (**Fig 2**) and segmental T1, T2, and $T2^{(sec)}$ histograms were generated.

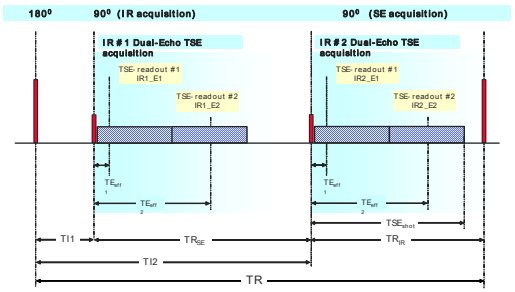


**Fig. 1**: Mixed turbo spin echo sequence.

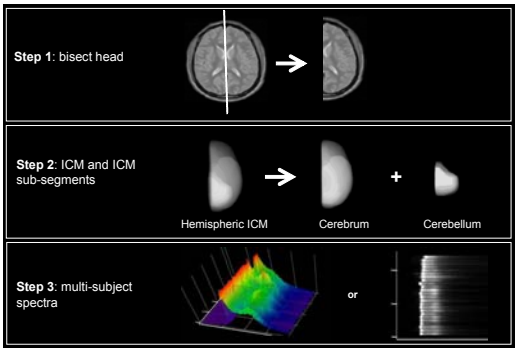


**Fig. 2**: Brain segmentation: dual space clustering, subsegmentation into four primary brain components

**Results:** High degree left-to-right symmetry was noted in theT1, T2, and $T2^{(sec)}$ cerebral and cerebellar spectra. The cerebral T1 spectra showed a strong age effect consisting in loss of white-to-gray matter peak separation and white matter shift towards longer T1 values (**Fig 3**). Weaker age effect in T1 spectra was seen in the cerebellum. Also, a residual age effect was observed in the combined T2 spectra, but effect is negligible in the $T2^{(sec)}$ spectra both in the cerebrum and cerebellum (**Fig 4**). The age effect was much weaker in the cerebellum.

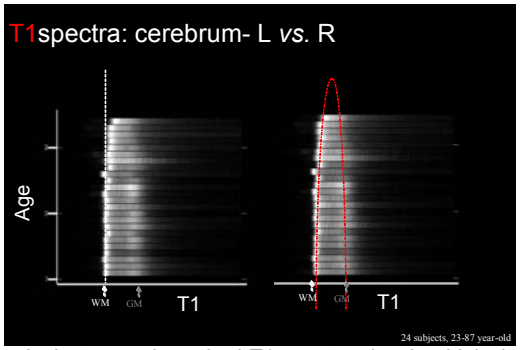


**Fig. 3**: Juxtaposed cerebral T1 spectra showing high degree of bilateral symmetry and a pronounced age effect.

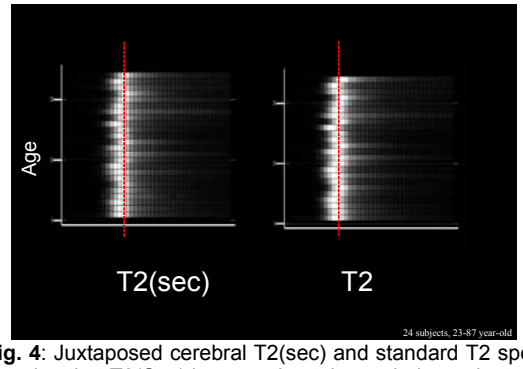


**Fig. 4**: Juxtaposed cerebral T2(sec) and standard T2 spectra showing that T2(Sec) is approximately age independent.

**Conclusion**: Strong age effect was noted in the T1 spectra in the cerebrum. By removing the T1 contribution, an age independent parameter, namely $T2^{(sec)}$ was found in the adult brain from 23 to 87 years of age. Described technique could be useful in the study of normal as well as pathologic brain aging.

## References

1. Brown MS, Gore JC. **NMR relaxation in tissue**. In NMR in medicine: the instrumentation and clinical applications. Stephen R Thomas and Robert L Dixon Editors. AAPM monograph 14, **1986**.
2. Jara H. **Volumetric mapping of the secular component of T2: a new application of the mixed-TSE pulse sequence**. Proceedings ISMRM 2005, South Beach Florida, USA.