

What new do we learn with Myelin Water Fraction in infant white matter bundles in comparison with other MRI parameters?

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Target audience: Myelination is an important mechanism in the maturation of the brain white matter. It starts late in the fetal development and continues until adolescence in an asynchronous manner across different cerebral regions¹. Myelination can be evaluated *in vivo* using conventional MRI and DTI parameters²⁻⁴; however, they provide only indirect measures of the myelin content and are also influenced by other tissue properties. Thus, scientists and clinicians may be interested in describing white matter maturation using a more direct measure of the myelin amount.

Purpose: The goal of the present study is to describe maturation asynchrony in infants across different white matter bundles using **Myelin Water Fraction (MWF)**, a novel MRI parameter of the brain myelin content, and compare it with other MRI parameters.

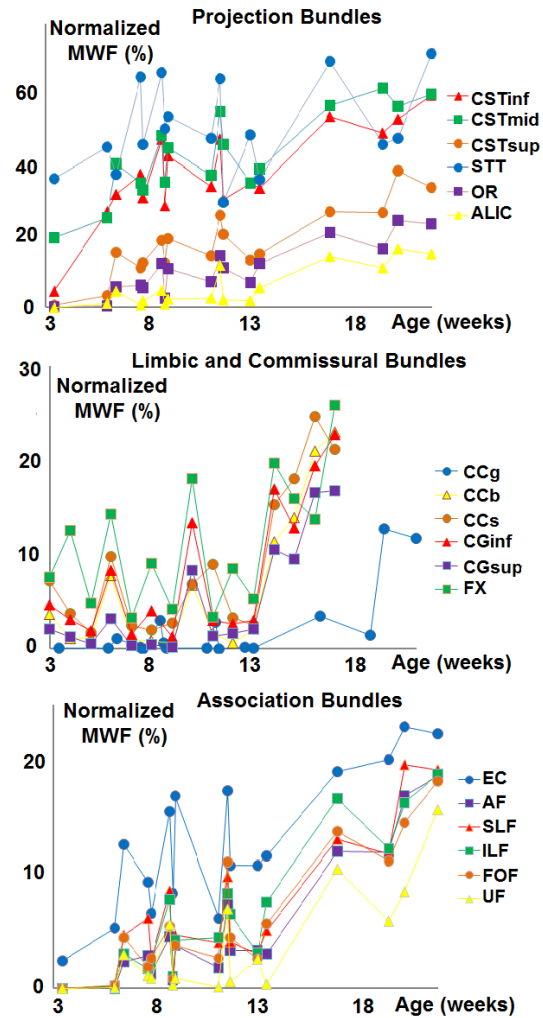


Fig. 1. MWF changes with age for different bundles (in % of the mean adult values).

Methods: *Subjects and Data Acquisition:* MRI and DTI data were acquired on a 3T system in 17 healthy infants (ages: 3 - 21 weeks) and 13 adults (mean age: 22.4±1.6 years). Whole brains were imaged with a 1.8mm isotropic resolution using EPI single-shot inversion recovery and spin-echo (IR-SE & spin-echo (SE) sequences: quantitative T1 (qT1) (inversion recovery with 8 values of the inversion time: TI=250->2500ms), qT2 (8 values of the echo time: TE=50->260ms) and DTI (30 orientations of diffusion gradients, b=700s.mm⁻²). *Post-processing of the data:* Quantitative maps for qT1, qT2 and DTI parameters (fractional anisotropy FA, mean <D>, longitudinal λ_{\parallel} and perpendicular λ_{\perp} diffusivities) were generated using Connectomist software⁵. MWF maps were computed using a multicomponent analysis of T1 and T2 relaxation signals adapted for infants⁶. 18 bundles were reconstructed in each subject using 3D tractography⁷ and manually delineated regions of interest⁸: cortico-spinal tract CST (inferior, middle and superior portions), spino-thalamic tract STT, optic radiations OR, anterior limb of the internal capsule ALIC, external capsule EC, arcuate fasciculus AF, superior SLF and inferior ILF longitudinal fascicles, uncinat fasciculus UF, fronto-occipital fasciculus FOF, fornix FX, inferior CGinf and superior CGsup parts of the cingulum; genu CCg, body CCb and splenium CCs of the corpus callosum. All parameters were quantified, averaged over the bundle length and normalized by the corresponding mean values from the adult group. *Comparison of the bundle maturation:* For each parameter pairwise comparisons between the bundles were performed over the infants group (paired t-test, significance level 0.95). Bundles were then ordered according to their relative degree of maturation. These bundle orders were compared across the parameters in terms of 1) number of discriminated relationships between the bundles; 2) agreement with 5 *a priori* known relationships: early maturation of STT, CST and OR; delayed maturation of ALIC and AF^{1,9-10}.

Results and Discussion: In adults, MWF values were highly variable across the bundles (from 0.14 in STT up to 0.36 on OR) and negatively correlated with qT1 ($R^2 > 0.94$). In infants, normalized MWF increased with age in all bundles in an asynchronous manner (Fig.1): certain bundles (STT, CST, EC, FX, OR) showed higher ratios and faster increase than others (ALIC, AF, UF, CC) (Fig.2). Surprisingly, ratios were relatively high in EC, and rather small in UF. Finally, bundle ordering was more accurate for MWF than for other parameters, revealing more maturational relationships and not violating *a priori* relationships (Fig.2, Tab.1).

Conclusions: MWF seems to be more accurate than univariate approaches based on conventional MRI/DTI parameters for description of the bundles maturation in infants.

Further comparisons with multiparametric models still need to be done.

References: 1. Yakovlev, Lecours (1967); 2. Dubois et al. (HBM, 2008); 3. Deoni et al. (NeuroImage, 2013); 4. Nossin-Manor et al. (NeuroImage, 2012); 5. Duclap et al. (ESMRMB 2012, #842); 6. Kulikova et al. (abstract submitted to ISMRM 2014, # 830); 7. Perrin et al. (Inf. Process Med Imaging ProcConf, 2005); 8. Huang et al. (MagnReson Med, 2004); 9. Paus et al. (Science, 1999); 10. Zhang et al. (NeuroImage, 2007).

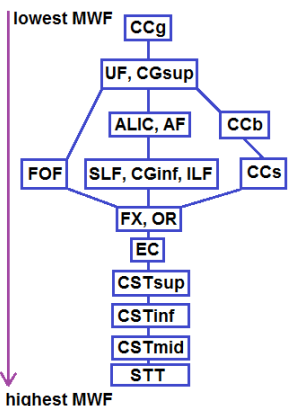


Fig. 2. Bundle ordering based on pairwise comparisons of the MWF.

Tab.1 Bundle ordering for different parameters: n - number of revealed relationships (max. possible 153), yes/no - presence of the violations of the known relationships.

	n	violations
MWF	129	no
qT1	91	yes
qT2	91	yes
FA	76	yes
<D>	77	yes
λ_{\parallel}	74	no
λ_{\perp}	86	yes