

# Assessment of the maturation of the optic radiation in children and adolescents with probabilistic tractography

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## Introduction

The bundles of white matter tracts composing the visual system are known through dissection studies to be myelin mature before the age of 3 years [1] and assumed to remain stable until adulthood. This work aimed at addressing the question of any age related change after early childhood within the visual pathway - more precisely within the optic radiation (OR) which extends from a nucleus of the thalamus to the primary visual cortex - and at assessing if any difference with respect to gender or hemisphere could be found. The study was carried out in-vivo with diffusion tensor imaging (DTI) on a cohort of 70 children and adolescents.

## Methods

**Subjects:** 70 healthy children (39 girls and 31 boys) with age ranging from 7 to 18 ( $11.45 \pm 2.47$  years) were studied from whom informed consent was obtained.

**DTI data acquisition:** Diffusion tensor imaging (DTI) data were obtained along 20 non-collinear directions, with b values of 0 and 1000  $s.mm^{-2}$  on a 1.5 T Siemens Avanto scanner using to a double refocused spin echo EPI sequence. The acquisition was repeated 3 times and the resulting volumes were composed of 45 contiguous 2.5 mm slices (averaged for two acquisitions with TE = 89 ms) with reconstructed voxel size 2.5 mm isotropic.

**DTI processing:** The diffusion tensor (DT) was fitted with linear least-square (with Camino [2]) after a preprocessing step correcting for head movements and eddy currents was applied by registering all volumes to the first b=0 volume with a 12-parameter affine transformation (with FSL [3]).

**Tractography:** Tractography was carried out using 10000 iterations of the PICO algorithm [4] without any angular threshold to allow for the high curvature of Meyer's loop and constraining ROIs as defined in [5]. DT indices within the segmented tracts were analysed for PICO threshold  $P_{thr} = 0.01\%$ , 0.1% and 1%.

**Quantitative and statistical analysis:** Change in the OR was evaluated by analysing change in DT parameters: the mean FA and axial ( $\lambda_{||}$ ) and radial ( $\lambda_{\perp}$ ) diffusivity which were computed in the segmented OR of each hemisphere. To assess any effects of gender or hemisphere, the computed DT parameters were subjected to a multiple regression analysis.

## Results

**Tractography** The OR could be reconstructed successfully with the PICO tractography method with Meyer's loop being visible in all subjects (cf. probability map in Figure 1 in which the probability range linearly from 0 in red to 1 in yellow).

**Quantitative and statistical analysis:** The three indices exhibited different patterns depending on gender and hemisphere.

**FA (Figure 2):** There was a significant age effect at every  $P_{thr}$  with the highest significance ( $p=0.00001$ ) obtained for  $P_{thr}=0.01\%$  for which the age coefficient was 0.004/year with 95% confidence interval [0.002,0.005]/year. There was no statistical evidence for any side (t-test p-value > 0.8 for all  $P_{thr}$ ) or gender effect ( $p > 0.3$  for all  $P_{thr}$ ).

**$\lambda_{||}$  (Figure 3):** There was strong evidence for a hemisphere effect ( $p < 0.00002$  for all  $P_{thr}$ ). No age effect was demonstrated for female ( $p > 0.24$  for all  $P_{thr}$  and both hemisphere) while an age effect was significant for males in the right hemisphere ( $p < 0.008$  for all  $P_{thr}$  with an age coefficient of -0.006 [-0.010; -0.002]  $\times 10^{-3} mm^2.s^{-1}/year$  at  $P_{thr}=0.01\%$ ) but not in the left ( $p > 0.24$ ).

**$\lambda_{\perp}$  (Figure 4):** There was also strong evidence for a hemisphere effect ( $p < 0.00008$  for all  $P_{thr}$ ). A significant age effect was shown for males both in the left ( $p < 0.01$  for all  $P_{thr}$  with an age coefficient of -0.007 [-0.011; -0.003]  $\times 10^{-3} mm^2.s^{-1}/year$  at  $P_{thr}=0.01\%$ ) and in the right hemisphere ( $p < 0.01$  for all  $P_{thr}$  with an age coefficient of -0.006 [-0.010; -0.002]  $\times 10^{-3} mm^2.s^{-1}/year$  at  $P_{thr}=0.01\%$ ) but only in the right hemisphere for females ( $p < 0.01$  for all  $P_{thr}$  with an age coefficient of -0.005 [-0.009; -0.001]  $\times 10^{-3} mm^2.s^{-1}/year$  at  $P_{thr}=0.01\%$ ).

## Discussion and conclusion

This study showed that changes are occurring in the optic radiation, and thus in the visual system, even after early childhood when the tracts are already myelin mature. The significant increase of FA with age was demonstrated with tractography in a large cohort ([6] based on a sample of 13 cases) and indicated a change in FA of 0.004/year. For the first time to our knowledge significant differences with respect to hemisphere and gender were found. The present work suggests ongoing structural development of the OR in children and adolescents and that these are subject to both the influences of gender and hemisphere.

## References

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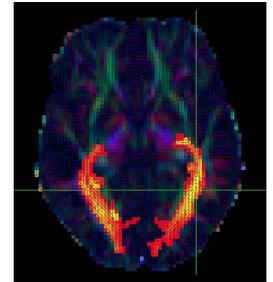


Figure 1: probability map from PICO algorithm at  $P_{thr} = 0.01\%$ .

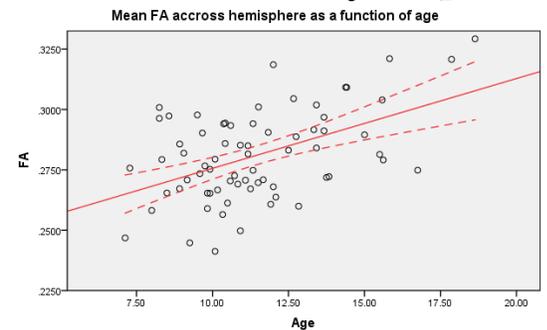


Figure 2: mean FA within the OR with respect to age at  $P_{thr} = 0.01\%$  ( $p = 0.00001$ ).

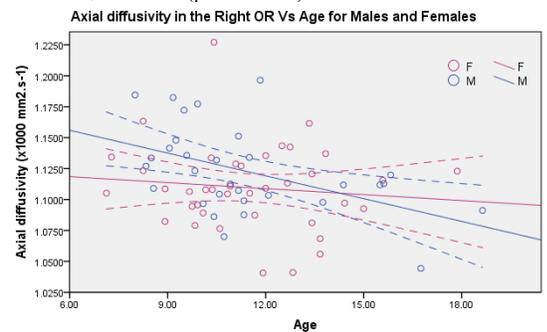


Figure 3: mean axial diffusivity within the right OR at  $P_{thr} = 0.01\%$ , for males (blue,  $p = 0.007$ ) and females (purple,  $p = 0.512$ ) with respect to age.

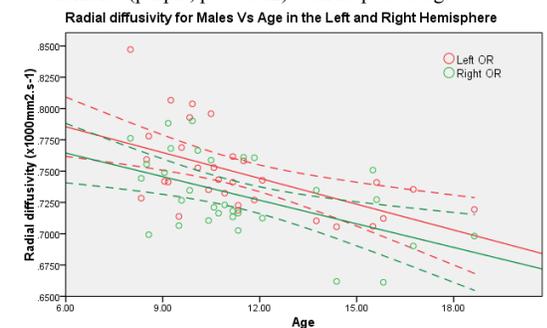


Figure 4: mean radial diffusivity for males at  $P_{thr} = 0.01\%$  within the left OR (red,  $p=0.001$ ) and the right OR (green,  $p = 0.003$ ) with respect to age.