Maturation of cerebellar afferent and efferent tracts in typically developed brains

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Introduction:

Ample neuroimaging evidences have strongly indicated that the human cerebellum is not only a sensory-motor organ but also involves many cognitive functions. And it is highly likely that these functions are supported by the anatomical entity of cerebellar afferent (cortico-ponto-cerebellar and spino-cerebellar) and efferent (superiorcerebellar) tracts (Strick et al., 2009). However, how these cerebellar tracts mature in typically developed brain is less understood, while some attempts have been made to understand developmental disorders (Catani et al., 2008). In the present study, we collected diffusion MRI from 69 (aged from 7 to 47 years) right-handed normal volunteers and addressed the question whether these cerebellar tracts parallely mature along with ages or the spino-cerebellar tract that mainly involves phylogenically-order sensory-motor functions develops first.

Methods:

Participants:
23 adult (ranged from 21-47, average 22.9 years old), 26 junior (ranged from 12-14, averaged 13.39 years old), and 20 child (8-11, averaged 9.48 years old) blindfolded volunteers participated in this study. All were right-handed with no history of neurological or psychiatric disease.

DTI analysis:
Diffusion MRI data were acquired for 30 diffusion-weighted directions and 1 non diffusion weighted volumes with voxel size 1 x 1 x 2 mm, FOV 256 x 256mm, 54 slices.

For analysis, at first, we corrected motion and geometrical distortions simultaneously by using Explore DTI (http://www.exploredti.com). Then, diffusion MRI was processed using StarTrack software (http://www.natbrainlab.com) (Dell'Acqua, 2013). Only one b-value was processed for deterministic spherical deconvolution tractography. To exclude spurious local maxima, we applied an absolute (threshold = 0.1) and a relative threshold (threshold = 10%). Streamlines were halted when a voxel without fiber orientation was reached or when the curvature between 1 steps exceeded a threshold of 35° . Tractography was imported to TrackVis and ROIs were manually drawn on cerebral and cerebellar regions: cerebral peduncle, superior, middle, and inferior cerebellar peduncles, and deep cerebellar nuclei (Catani et al., 2008). Using these ROIs, long afferent (cortico-ponto-cerebellar and spino-cerebellar tracts) and efferent (superiorcerebellar tract) connections were reconstructed. For the analysis, we calculated Hindrance Modulated Orientational Anisotropy (HMOA) for each tract of each hemisphere in each participant separately. HMOA is thought to be highly sensitive index for depicting changes in fiber diffusivity and differences in the microstructural organization of white matter, and thus is believed to be useful to characterize the degree of maturation of a specific tract in a developing brain (Dell'Acqua, 2013). For statistical evaluation, we first performed one-way ANOVA (adult, junior, child) for HMOA value for each tract in each hemisphere, and used multiple comparison of Tukey's test to evaluate sub effects.

Results:

Adult group showed greater HMOA value in the left spino-cerebellar tract and in the bilateral superior-cerebellar tracts, when compared with child and junior groups. In addition, the group also showed greater HMOA value in the right spino-cerebellar tract and in the right cortico-ponto-cerebellar tract, when compared with child group but not with junior group. Finally, junior group had greater HMOA value in the left spino-cerebellar tract when compared with child group.

Conclusions:

These results indicate that all of the cerebellar afferent (cortico-ponto-cerebellar and spino-cerebellar) and efferent (superiorcerebellar) tracts parallely mature along with ages, which generally fits well with the age-dependent maturation of cerebro-cerebellar resting-state functional connectivity (Dosenbach et al., 2010).

Lifespan Development:

Normal Brain Development: Fetus to Adolescence [2]
Lifespan Development Other [1]

Poster Session:

Poster Session - Tuesday

Keywords:

Development
WHITE MATTER IMAGING - DTI, HARDI, DSI, ETC
Other - cotico-cerebellar tracts, longitudinal study

[1|2]Indicates the priority used for review

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Please indicate which methods were used in your research:

Diffusion MRI

For human MRI, what field strength scanner do you use?

3.0T

Which processing packages did you use for your study?

Other, Please list - TrackVIs, StarTrack

Provide references in author date format

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