Infant connectivity fingerprint distinguishes familial risk of dyslexia and predicts long-term literacy development

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Introduction

- Developmental dyslexia is a learning disability characterized by difficulties in word reading. Higher dyslexia liability (40-60%) has been reported for children with a familial risk compared to a general prevalence of 3-5% in children with no familial risk *(Snowling and Melby-Lervåg, 2016)*.
- Several dyslexia-susceptibility genes have been proposed to play an important role in early brain development, including in neuronal migration, axonal growth and cilia function, which may lead to disruptions in the cortico-cortical circuits critical for learning to read *(Galaburda et al., 2006; Giraud & Ramus, 2013)*.
- Atypical white matter structure and neural responses to fine-grained auditory properties have already been observed in newborns with family history of dyslexia (FHD+) compared to FHD- controls *(Langer et al., 2017 ; Leppanen et al., 2010)*.

Research Questions

1) Does a familial risk for dyslexia associate with atypical functional connectome in early infancy as measured by resting-state functional connectivity (FC)?
2) Are FC patterns in early infancy associated with subsequent development of foundational literacy skills in school age or beyond?

Participants

At infancy: resting-state images were available for 98 infants, 32 (20 males) with 1st degree relatives with dyslexia (FHD+) and 66 (28 males) without (FHD-). The two groups were balanced on age (8.4±2.3 months), birth weight (7.3±1.2 lbs) and height (20.0 ±1.9 cms).

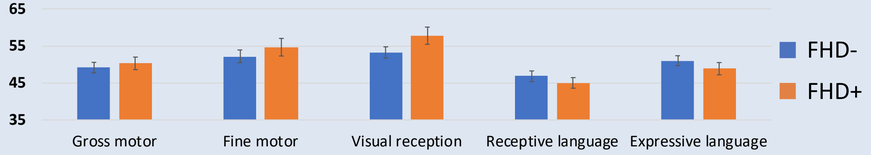


Table 1. No group differences were observed for the Mullen Scales of Early Learning

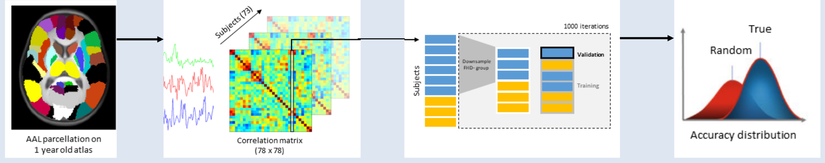
At school age: 34 participants were invited back at 6 years old (5.5 ± 1.0 years) and assessed on preliteracy skills, including rapid automatized naming (CTOPP-2, Wagner et al., 1999) and phonological processing (WJ-IV, Schrank et al., 2018).

Resting-State Functional Imaging Processing

- Images were visually inspected to exclude subjects with poor data quality and atypical brain anatomy.
- Slice timing and rigid body alignment were applied, and head movement during resting-state acquisition was estimated.
- Scans with excessive motion were detected using the criteria of framewise displacement (FD) larger than 0.3 mm, and all subjects included in the current analyses had scans with duration of at least 4 minutes after volume censoring.
- Images were then spatial normalized to an age-matched infant AAL templates *(Shi et al., 2011)*, subjected to linear regression to remove head motion, CSF/WM signals and motion spike, temporal band-pass filtered (0.01-0.1Hz) and spatially smoothed (FWHM = 6mm).

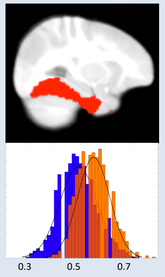
Classification between FHD+ and FHD- infants

Analyses



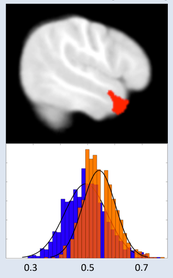
Results

Left fusiform gyrus



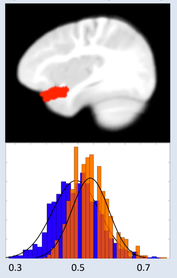
Cohen's *d* = 0.87

Left middle temporal pole



Cohen's *d* = 0.70

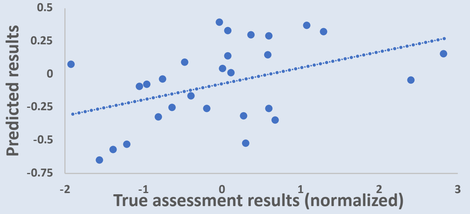
Right superior temporal pole



Cohen's *d* = 0.68

Longitudinal Prediction

- **Phonological processing abilities (Left middle temporal pole)**



mean *r* = 0.44;
Cohen's *d* = 1.4

- **Rapid automatized naming**

No region showed significant associations between its FC pattern and performance on rapid automatized naming at age 6.

Discussion

- The functional connectivity patterns associated with temporal regions were altered in infants with familial risk of dyslexia, indicating that the atypical development of the functional network underlying auditory and language processing, often observed in individuals with dyslexia, may originate from infancy.
- Infant functional topologies associated with familial risk of dyslexia were predictive of phonological processing abilities estimated at 6 years old. This suggests a neural network mechanism associated with the early effect of familial risk of dyslexia may serve as a crucial neural foundation for long-term literacy development

References

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