Atypical developmental trajectory of print-speech convergence in children and adults with reading disability: an integrative perspective

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Introduction

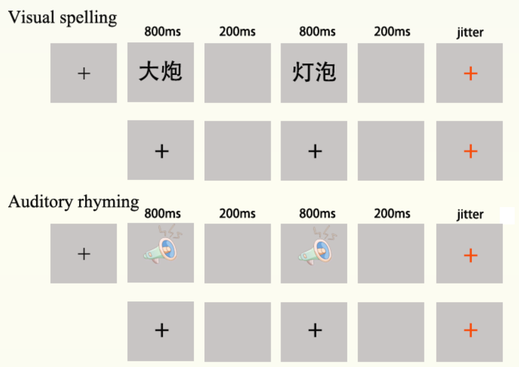
About 5-10% of children in alphabetic languages (Katusic et al., 2001; Shaywitz, 1996) and about 4-7% of children in logographic languages (Sun et al., 2013; Uno et al., 2009; Zhao et al., 2016) suffer in learning to read. Many studies have been conducted for the etiology of reading disability, however, it is still in debate. Recently, a multiple deficits perspective has been proposed (Ring & Black, 2018), and phonological deficit and visuo-orthographic deficit may both lead to reading disability. Previous studies has well documented the contribution of the visuo-orthographic system and language system to fluent reading, and found brain coactivation to the visual words and speeches can predict reading performance (Marks et al., 2019; Preston et al., 2016). The coactivation brain network when performing speech processing task and visual word reading tasks is defined as print-speech convergence and it may act as a quantitative measurement of functional reshaping of language system, and the failure of functional reshaping of the language system may capture the core feature of reading disability. To test the hypothesis directly, we ran a cross-sectional study using representational similarity analysis (RSA) to explore the difference of print-speech convergence between typical readers and readers with reading disability in both the children group and the adults group.

Method

Participants

	Children		Adults	
Group	CAC	CRD	AAC	ARD
N (Male)	30 (9)	35(23)	34 (11)	30 (10)
Age (months)	134.57±2.15	132.29±1.99	248.12±2.02	252.80±2.15
IQ	104.13±8.49	100.26±10.55	119.65±13.47	113.97±14.48

The experimental Design



Apparatus 3.0 T Siemens MRI scanner

Scan parameters 34 contiguous axial slices, 3 mm thickness, TR = 2000 ms, flip angle = 80° , TE = 20 ms, in-plane resolution = 1.7 × 1.7 mm, matrix = 128 × 128. High resolution T1-weighted 3D images were acquired with following parameters: axial slices = 160, slice thickness = 1 mm, TR = 2300 ms, flip angle = 9° , TE = 3.24 ms, FOV = 260 mm, matrix = 256 × 256.

Data Preprocessing

Results

Traditional whole brain analysis

1. Readers with reading disability and age-control readers showed different brain coactivation in children group and adults group.

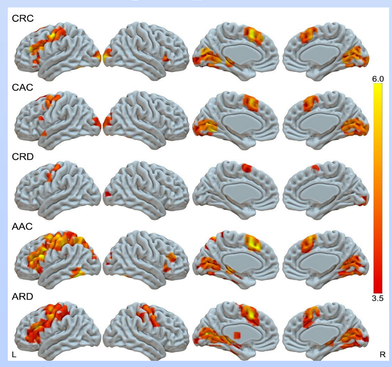


Fig 1. whole-brain coactivation map of auditory rhyming task and visual spelling task for each group

Representational similarity analysis

2. Readers with reading disability showed lower print-speech convergence and than typically developing readers left IFG, left MFG, bilateral IPL and bilateral calcarine gyrus; adults showed higher print-speech convergence than children around peryselvian regions.

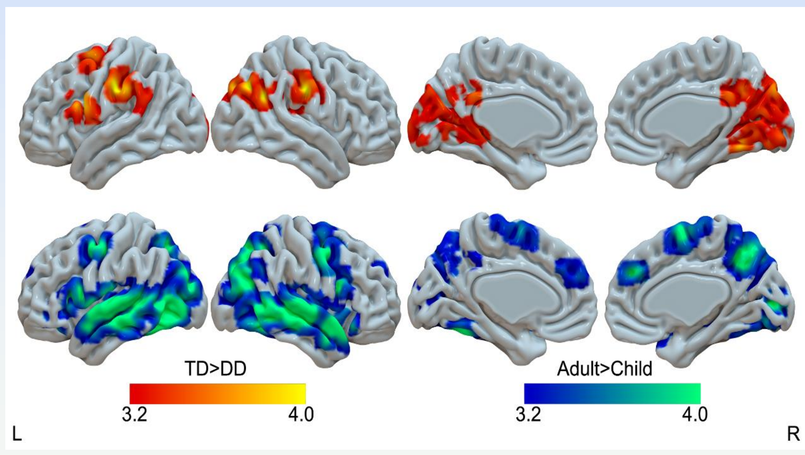


Fig. 2 Main effect of group and main effect of age

3. Children showed specific print-speech convergence deficit in bilateral cerebellum, left postcentral gyrus and right percental gyrus.

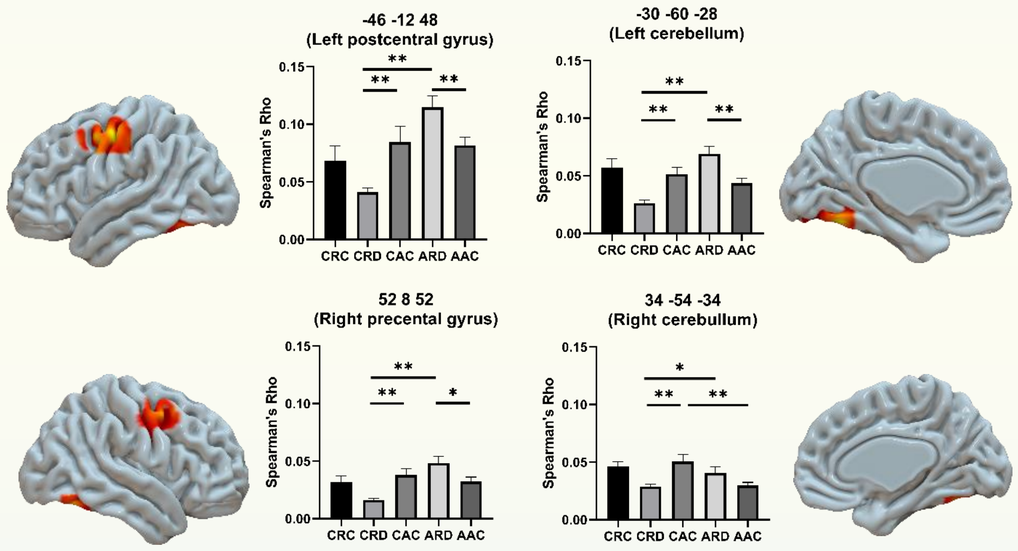


Fig. 3 Children specific deficit in print-speech convergence

Conclusions

In this study, we found persistent reduction of print-speech convergence in the left fusiform gyrus, inferior parietal cortex and inferior frontal cortex over development, which cannot be interpreted as a result of being RD, but should be interpreted as a developmental deviance, since reading level controls also showed greater convergence than individuals with RD. There are also brain regions that showed convergence reduction only in children with RD, suggesting developmental delay. This suggests the print-speech convergence deficit of the brain can serve as a neural signature of RD, and RD is likely to result from the failure of brain functional reshaping during reading acquisition.

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