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Neural mechanisms of abnormal reading processing in Chinese children with developmental dyslexia: An ALE and MACM meta-analysis

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ADMINISTRATIVE INFORMATION

Support - None.

Review Stage at time of this submission - Risk of bias assessment.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 2 August 2026 and was last updated on 2 August 2026.

INTRODUCTION

Review question / Objective The authors conducted a comprehensive meta-analysis of task-based functional magnetic resonance imaging studies examining reading processing in individuals with Developmental dyslexia.

Condition being studied Children with developmental dyslexia.

METHODS

Participant or population Children with developmental dyslexia; Typically developing children.

Intervention None.

Comparator Typically developing children.

Study designs to be included Case-control study and cohort study.

Eligibility criteria 2.2.1 Inclusion criteria
Studies were included in the present meta-analysis if they met all of the following criteria: (1) studies that compared brain activation differences between children and adolescents with Chinese developmental dyslexia (DD) and typically developing (TD) controls during reading-related tasks, including semantic, phonological, and orthographic processing tasks; (2) studies that employed task-based functional magnetic resonance imaging (fMRI); (3) studies in which DD was defined according to explicit diagnostic criteria, using standardized reading assessments or reading tests based on local norms, with specific cutoff values reported; (4) studies that reported peak activation coordinates in the standardized Montreal Neurological Institute (MNI) or Talairach space based on whole-brain analyses; (5) studies that reported between-group contrasts between the DD and TD groups; (6) original research articles published in peer-reviewed journals; and (7) studies involving participants younger than 18 years.

2.2.2 Exclusion criteria
Studies were excluded if they met any of the following criteria: (1) studies using magnetoencephalography (MEG), electroencephalography (EEG), transcranial magnetic stimulation (TMS), eye-tracking, other behavioral methods, structural MRI, or diffusion tensor imaging (DTI), as well as review articles and meta-analyses; (2) studies reporting only within-group comparisons; (3) studies including children or adolescents with partially remitted DD symptoms, because the similarity of their neural mechanisms to those of individuals with full-syndrome DD remains unclear; (4) studies without baseline fMRI data; (5) studies from which peak activation coordinates could not be obtained; (6) studies based on non-seed methods; and (7) studies based on publicly available neuroimaging databases, such as OpenNeuro.

Information sources Databases were search (PubMed, The Cochrane Library, Web of Science, EBSCO, Embase) up until 20th July 2026. Reference lists of included studies will be scanned for further relevant literature.

Main outcome(s) Based on the perspective that developmental dyslexia is a disorder reflecting dysfunctions in large-scale neuronal systems, we interpreted abnormally activated brain regions identified in our meta-analysis as dysfunctional nodes within large-scale networks described in the current neuroscience literature.Based on the perspective that Developmental dyslexia is a disorder reflecting dysfunction of large-scale neuronal systems , we interpreted abnormally activated brain regions from our meta analysis as dysfunctional nodes of large-scale networks described in the current neuroscience literature.

Quality assessment / Risk of bias analysis The quality and completeness of the included studies were assessed using a 10-item checklist. Furthermore, the Fail-Safe N (FSN) method was employed to assess the extent to which unpublished negative findings and potential publication bias might influence the stability of the current results.

Strategy of data synthesis Aggregate data will be used for quantitative coordinate-based ALE meta-analyses. Analyses will be performed using BrainMap GingerALE version 3.02. We will adhere to the ALE method developed by Eickhoff et al. (http://www.brainmap.org/ale/). A p value will be calculated for each voxel based on the probability of obtaining an ALE value that differs from the corresponding voxel in a null-distribution map. In all analyses, statistical significance will be assessed using a cluster-level family-wise error (FWE)-corrected threshold of $p < 0.05$, with a cluster-forming threshold of $p < 0.001$ and 5,000 permutations. All parameters were set according to the recommended standard settings of GingerALE.

Subgroup analysis In the present study, we performed a quantitative activation likelihood estimation (ALE) meta-analysis to systematically characterize abnormal neural activation patterns in children with developmental dyslexia (DD) across multiple reading-related processes. Going beyond previous investigations that have focused on isolated reading components, we examined phonological, semantic, and orthographic processing tasks to identify the shared neural substrates underlying reading impairments as well as process-specific neural alterations in Chinese children with DD.

Sensitivity analysis The stepwise exclusion method was used to assess heterogeneity.

Country(ies) involved China.

Keywords Developmental dyslexia; Chinese children; Reading processing; Functional magnetic resonance imaging; Activation likelihood estimation.

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