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Brain activation and coactivation during action observation and imitation in autism spectrum disorder: An ALE and MACM meta-analysis

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ADMINISTRATIVE INFORMATION

Support - None.

Review stage at the time of initial registration - Data extraction.

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 8 January 2026 and was last updated on 15 November 2026.

INTRODUCTION

Review question / Objective This review compared activation convergence during action observation and imitation between individuals with autism spectrum disorder (ASD) and typically developing (TD) individuals. Adult and child-adolescent studies were analyzed separately. Literature-based coactivation of regions showing between-group differences was characterized using exploratory MACM analyses added after registration.

Condition being studied Autism spectrum disorder is characterized by difficulties in social communication and interaction and by restricted or repetitive behaviors. Whether mirror neuron system dysfunction contributes to difficulties in action observation and imitation remains debated.

METHODS

Participant or population People with autism spectrum disorder.

Intervention None.

Comparator People with normal development.

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

Eligibility criteria
Original task-based fMRI studies published in Chinese or English were eligible without a publication-year restriction. Studies were required to include participants with ASD and a TD control group, or to report ASD results separately when other clinical groups were enrolled. Eligible contrasts had to examine non-emotional action observation and/or imitation and report significant whole-brain activation coordinates for the ASD and/or TD group in Talairach or MNI space. Studies reporting only region-of-interest results, ineligible tasks, resting-state data, or non-fMRI findings were excluded.

Information sources PubMed, Cochrane Library, Web of Science, EBSCO (MEDLINE, APA

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PsycINFO, and ERIC), Embase, Scopus, CNKI, and Wanfang were searched from inception to 5 January 2026. Reference lists of relevant systematic reviews of fMRI studies in autism published during the preceding decade were also screened.

Main outcome(s) The main outcomes were the locations of activation convergence in ASD and TD, shared convergence between the groups, and activation-convergence differences in the ASD > TD and TD > ASD contrasts during action observation and/or imitation.

Additional outcome(s) Additional outcomes were exploratory activation-convergence patterns in separately analyzed adult and child-adolescent studies and literature-based coactivation patterns assessed by MACM. MACM seeds were selected post hoc from the between-group contrast results.

Quality assessment / Risk of bias analysis Two authors applied a 10-item checklist to assess reporting completeness and study characteristics. The checklist was not treated as an assessment of overall methodological quality or risk of bias. Fail-Safe N assessed the robustness of ALE clusters to simulated null-result studies; it could not rule out publication bias.

Strategy of data synthesis Single-group ALE and per-seed MACM maps used an uncorrected voxel-level cluster-forming threshold of $p < 0.001$, cluster-level FWE-corrected $p < 0.05$, and 1,000 permutations. Conjunction maps represented the voxelwise minimum of the thresholded single-group maps without a separate permutation test. Bidirectional between-group contrasts used the FWE-corrected single-group maps as input, 10,000 permutations, uncorrected voxel-level p 150 mm^3. The contrast maps themselves were not FWE-corrected. MACM seeds were selected post hoc from all clusters meeting the between-group contrast threshold.

Subgroup analysis Adult studies (mean sample age ≥18 years) and child-adolescent studies (mean sample age <18 years) were analyzed separately for ASD and TD using the corresponding whole-sample analysis parameters. No direct comparison between the adult and child-adolescent subgroups was performed.

Sensitivity analysis The stepwise exclusion method was used to assess heterogeneity.
Language restriction Chinese; English.

Country(ies) involved China.

Keywords Autism spectrum disorder; Mirror neuron system; Action observation; Imitation; Activation likelihood estimation; Meta-analytic coactivation modeling.

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Other relevant information This is a post-registration amendment. The protocol was registered on 8 January 2026, when the review was at the data-extraction stage. Subsequent reanalysis changed the statistical thresholds, added or expanded age-stratified and sensitivity analyses, and introduced exploratory MACM analyses. MACM seeds were selected after inspection of the contrast results and were not prespecified in the original protocol.

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