

INPLASY

A Scoping Review of Resting-State fMRI and Machine Learning Methodology Pipelines Applicable to Convergence Insufficiency

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ADMINISTRATIVE INFORMATION

Support - None.

Review Stage at time of this submission - Completed but not published.

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 14 June 2026 and was last updated on 14 June 2026.

INTRODUCTION

Review question / Objective OBJECTIVES:

R (a) To synthesize existing evidence from studies of strabismus, specifically exotropia to evaluate how effectively resting-state fMRI signals distinguish disease status and subtypes using statistical and/or machine learning approaches, based on reported classification performance.

(b) To assess the applicability of the methodological pipelines identified in exotropia studies to similar research in convergence insufficiency.

RESEARCH QUESTIONS

RQ1: Which methodology pipeline can be applied to similar research in convergence insufficiency?

RQ2: Which are the primary networks affected in exotropia?

Background Convergence insufficiency (CI) is a common binocular vision disorder that can impair

reading, academic performance, and quality of life. Resting-state functional magnetic resonance imaging (rs-fMRI) has identified neural network alterations in related forms of exotropia, and machine learning methods have shown promise for disease classification using these imaging features. However, no synthesis has evaluated whether the methodological pipelines developed in exotropia can be applied to CI. This scoping review aims to identify and summarize these approaches and their potential applicability to future CI research.

Rationale There is currently no published synthesis of rs-fMRI-based methodological pipelines that can be applied to machine learning research in convergence insufficiency. Because direct neuroimaging and machine learning studies in CI are scarce, evidence from related forms of exotropia may provide a transferable framework for feature selection, analytical methods, and classifier development. This scoping review was therefore undertaken to map the existing evidence and

identify methodologies applicable to future CI research.

METHODS

Strategy of data synthesis Search Strategy

Patient condition: (Ocular motility disorders , Vergence disorder, Strabismus, exotropia, convergence insufficiency)

AND

Intervention : (fMRI, rs-fMRI) AND (Machine learning, support vector machine, deep learning, pattern recognition) AND (visual cortex, visual network, saccade, eye movement, oculomotor) AND (ALFF, fALFF, BOLD, ReHo, connectivity).

Eligibility criteria Study designs - Randomized control trials, observational studies - prospective, retrospective, cross sectional case control

Study subject - Analysis of alterations in functional connectivity in clinical condition using fMRI signals

Accuracy metrics for distinguish patients from healthy controls - with or without machine learning algorithms

English language studies

Minimum sample size of 20 patients

Drop out rates lower than 20%.

Source of evidence screening and selection

Three electronic database searches - PUBMED, Scopus and Web of Science

Manual de-duplication (possible due to small number of studies retrieved) with verification or searches and selection of articles by two human reviewers.

Data management One Excel file with data extracted into 4 separate worksheets - Patient characteristics, study characteristics, Outcomes and Risk of bias assessments - served as the basis for analysis. Extraction was performed with the AI-assistance (Anthropic) and every item verified manually by the author.

Patient characteristics - Age and gender profile of participants, the clinical condition studied, the make of the scanner used to capture data and the participant assessments Sample size, Mean age +/- Standard deviation, gender split in patients and healthy controls

Study Characteristics - the purpose, the design, sample size, inclusion and exclusion criteria, fMRI type and signals analyzed, brain regions involved, machine learning algorithms employed, if any, and statistical methods to distinguish disease subtypes.

Outcomes- Performance metrics, results and alterations in functional connectivity reported.

Reporting results / Analysis of the evidence

Narrative synthesis

A structured narrative synthesis was conducted. Quantitative meta-analysis was not performed due to heterogeneity in neuroimaging parameters, preprocessing pipelines, functional connectivity metrics, machine learning algorithms, and outcome reporting formats across included studies.

Presentation of the results Results were presented in the following forms :

- Prisma flow diagram for results of search methodologies

- Tables to depict patient characteristics, study characteristics, outcomes and risk of bias analysis.

Language restriction English only.

Country(ies) involved United States.

Keywords convergence insufficiency, exotropia, strabismus, resting-state fMRI, functional connectivity, machine learning, ALFF, ReHo.

Dissemination plans Findings will be submitted for publication in a peer-reviewed vision science journal. Results may additionally be presented at relevant academic or clinical conferences in ophthalmology and vision science.

Contributions of each author

Author 1 - Sandhya Rajagopal - Performed the searches, screened articles, managed data, drafted the manuscript.

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Author 2 - Barbara Tafuto - Provided guidance in preparing search strategies, executing them, data management and manuscript preparation.

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