Cognitive Skills Model for Predicting Alzheimer's Disease

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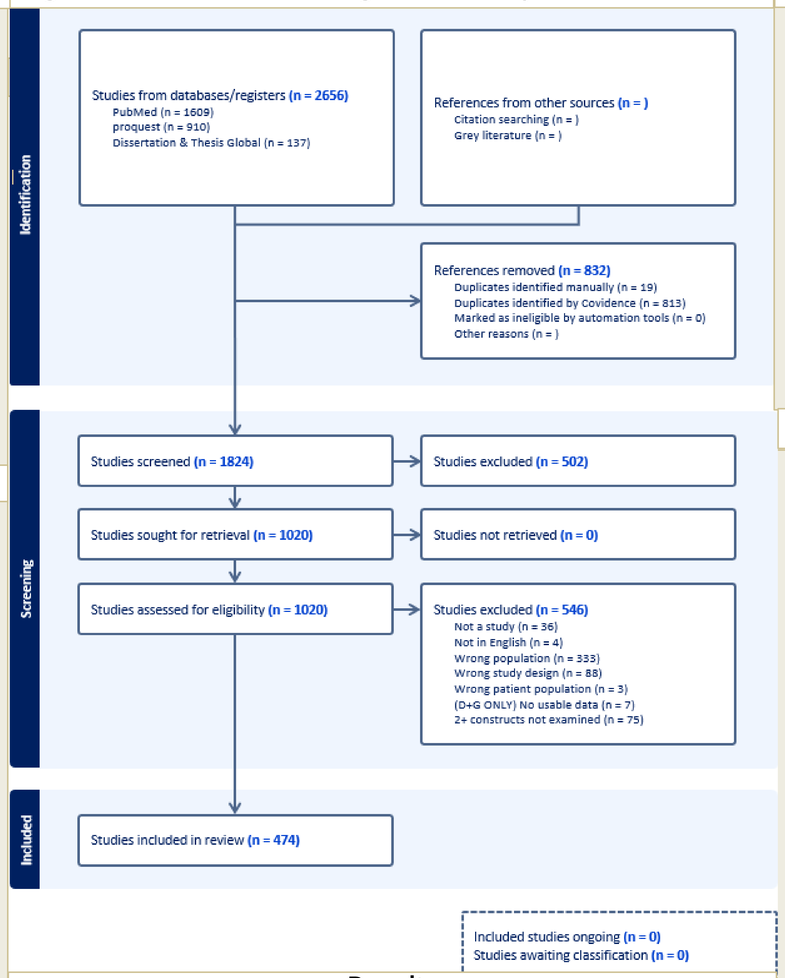
Introduction

- Dementia is a brain condition that affects memory and thinking and can make daily activities harder for older adults (World Health Organization [WHO], 2025).
- Alzheimer's disease (AD) is the most common form of dementia, and many people first experience mild cognitive impairment (MCI) (National Institute on Aging [NIA], 2021, 2025).
- Researchers have found that problems with spatial navigation, may appear early and can reflect possible AD in people with MCI (Laczó et al., 2022; M. Laczó et al., 2024).
- Spatial navigation is not used as often as traditional memory tests, and previous research has not fully examined how these skills change in MCI or how well they predict Alzheimer's disease (Laczó et al., 2022; M. Laczó et al., 2024).
- The purpose of this study is to better understand which MCI-related factors, including spatial navigation skills, are most helpful in identifying early signs of Alzheimer's disease.
- Using a model-based meta-data analysis, this research reviews existing human studies to compare cognitive, biological, and demographic predictors, with the goal of improving early diagnosis and supporting better tools for identifying individuals at higher risk.

Methods

- All methods were done in accordance with PRISMA guidelines.
- Study participants: Older adults with MCI, healthy older adults as controls (HC).
- Units of analysis: peer-reviewed studies, eligible grey literature, and theses.
- We entered the search string "tiab((executive OR processing OR flexibility OR inhibit* OR planning OR attention OR language OR fluency OR memory)) AND tiab((spatial OR visuospatial OR navigation)) AND tiab(("Mild Cognitive Impairment" OR MCI))" into the databases PsychInfo, PubMed, AgeLine, Web of Science, and ERIC. We imported all relevant studies into Covidence. PRISMA flowchart included as Fig. 1.
- We then completed a title and abstract screening and later a full text screening with the following criteria:
  - Examines MCI individuals without comorbidities
  - English empirical studies on human studies that focused on dementia, MCI or Alzheimer's Disease.
  - Examines 2+ constructs related to cognition or spatial function
    - (Episodic Memory, Working Memory, Executive Function, Processing Speed, Attention, Language Functions, Visuospatial Ability, Spatial Navigation, Fluency, or Experimenter-created tasks assessing these constructs)
  - The study design has healthy controls and uses either a correlational design or a group comparison design.
- We then completed an extraction of the data using Covidence using a standardized template. Two reviewers worked on each study and extracted the following information.
  - Title and authors
  - Participant Data (number of MCI, Healthy Controls, and subgroups)
  - Description, Mean, SD of each reported task. Example task included as Fig. 2.
- Global/composite cognitive totals (Total MoCA/MMSE) were not included. Extraction prioritized subtests/domain scores for eligible constructs.
- Statistical analyses were then performed and followed by sensitivity analyses to verify the data.

Figure 1. PRISMA Flow Diagram of Study Selection Process



Results

- Preliminary analysis worked with 138 effect sizes from 52 studies.
- Data indicated that older adults with MCI performed significantly worse at spatial navigation tasks when compared to healthy controls with a large effect size (Hedges' g = 0.81, p < .001).
- Presents significant evidence for the use of spatial navigation as a measure of cognitive decline although the study is still ongoing as we strengthen the results with data from more studies.
- Is the first meta-analysis which examines the connection between MCI and spatial navigation exclusively and is at present the largest database of spatial navigation task data in adults with MCI.
- Revealed possible connections to percentage of male participants, matrix-based tasks, and MCI diagnostic criteria which presents opportunity for future study.
- Results support the use of spatial navigation as an indicator of early MCI development while revealing the need for a more standardized approach towards spatial navigation assessment.

Discussion

- Older adults with MCI performed worse than healthy older adults on spatial navigation tasks which may be an early indicator of cognitive decline and potential Alzheimer's risk.
- The large effect size suggests a meaningful, clinically relevant group difference with stable findings across sensitivity analyses.
- Differences in navigation measures and MCI definitions likely explain inconsistent results across studies.
- Moderator patterns suggest study characteristics (for example, sex composition and diagnostic criteria) may influence effect sizes.
- Spatial navigation should be used as an add-on to traditional cognitive testing, not a stand-alone diagnosis.
- Future research should use longitudinal designs, improve demographic/clinical reporting, and test whether navigation deficits can be improved with training/rehab.

References

Laczó, M., Martinkovic, L., Lerch, O., Wiener, J. M., Kalinova, J., Matuskova, V., Nedelska, Z., Vyhnalek, M., Hort, J., & Laczó, J. (2022). Different profiles of spatial navigation deficits in Alzheimer's disease biomarker-positive versus biomarker-negative older adults with amnestic mild cognitive impairment. Frontiers in Aging Neuroscience, 14, 886778. https://doi.org/10.3389/fnagi.2022.886778

Laczó, M., Svatkova, R., Lerch, O., Martinkovic, L., Zuntychova, T., Nedelska, Z., Horakova, H., Vyhnalek, M., Hort, J., & Laczó, J. (2024). Spatial navigation questionnaires as a supportive diagnostic tool in early Alzheimer's disease. iScience, 27(6), 109832. https://doi.org/10.1016/j.isci.2024.109832

National Institute on Aging. (2021, April 12). What is mild cognitive impairment? https://www.nia.nih.gov/health/memory-loss-and-forgetfulness/what-mild-cognitive-impairment

National Institute on Aging. (2025, March 4). What is Alzheimer's disease? https://www.nia.nih.gov/health/alzheimers-and-dementia/what-alzheimers-disease

World Health Organization. (2025, March 31). Dementia. https://www.who.int/news-room/fact-sheets/detail/dementia

Han, K., Park, K., Choi, K.-H., & Lee, J. (2021). Mobile augmented reality serious game for improving old adults' working memory. Applied Sciences, 11(17), Article 7843. https://doi.org/10.3390/app11177843

Figure 2. Trail Making Test (TMT-A / TMT-B)