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INTRODUCTION

- Evidence on cognitive reserve from non-Western settings is limited.
- Cognitive reserve may preserve cognitive function despite age-related brain pathology or structural injury.^{1,2}
- Most MRI-based evidence comes from highly educated Western populations; India offers a distinctive setting because many older adults experienced barriers to formal schooling.³

OBJECTIVE

- Test whether formal education modifies associations between structural brain integrity and cognition among older adults in India.

METHODS

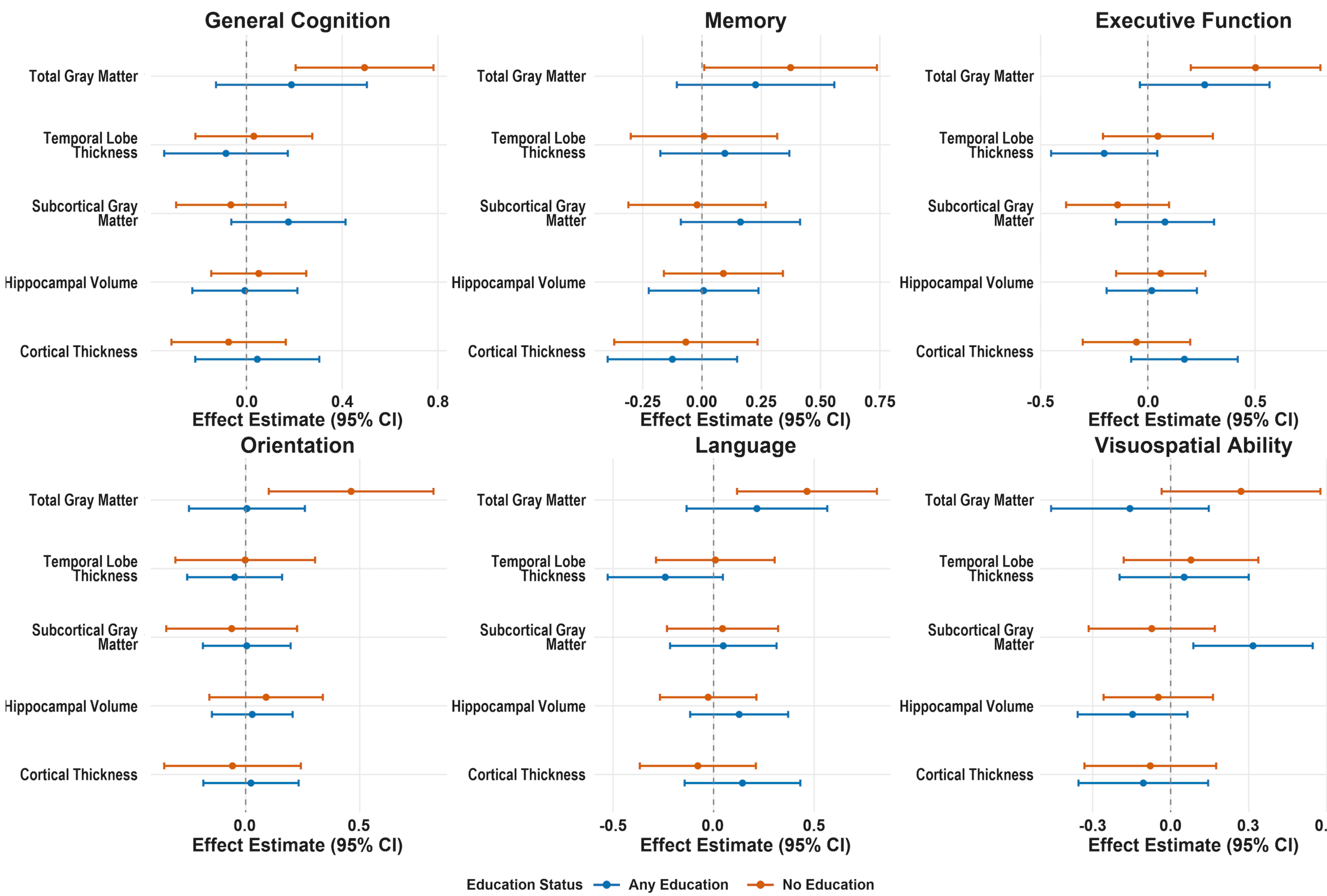
- Cross-sectional LASI-DAD Wave 2 MRI sub-study, 2022-2025: 400 adults age 60 or older; 198 with no formal education and 202 with any formal education.
- T1-weighted MRI measures: total gray matter, hippocampal and subcortical gray matter volumes, cortical thickness, and temporal lobe thickness.
- Cognitive outcomes used Harmonized Cognitive Assessment Protocol (HCAP) measures⁴: general cognition, memory, executive function, orientation, language fluency, and visuospatial ability; all measures were z-standardized.
- Multivariable linear regression tested MRI-by-education interactions and educational status-stratified associations.
- Models adjusted for age, sex, intracranial volume, interview-to-MRI time interval, and the other MRI measures.

Table 1. Selected characteristics by education status

Characteristic	Overall (n=400)	No education (n=198)	Any education (n=202)
Age, years	69.67 (6.00)	68.90 (5.93)	70.42 (6.00)
Female	204 (51.0%)	135 (68.2%)	69 (34.2%)
General cognition	0.30 (0.76)	-0.09 (0.61)	0.69 (0.69)
Memory	0.25 (0.76)	0.06 (0.74)	0.44 (0.73)
Executive function	0.19 (0.78)	-0.20 (0.65)	0.58 (0.69)
Orientation	0.21 (0.62)	-0.09 (0.61)	0.50 (0.46)
Language/fluency	0.26 (0.63)	0.10 (0.59)	0.42 (0.62)
Visuospatial	0.25 (0.70)	-0.12 (0.58)	0.61 (0.61)
Gray matter volume, mm ³	516,604 (47,387)	505,537 (45,549)	527,453 (46,746)
Hippocampal volume, mm ³	7,377 (823)	7,264 (814)	7,488 (819)
Subcortical gray matter volume, mm ³	47817.62 (4490.76)	46970.27 (4376.12)	48648.20 (4456.78)
Cortical thickness, mm	2.40 (0.08)	2.40 (0.08)	2.39 (0.08)
Temporal lobe thickness, mm	2.70 (0.10)	2.71 (0.10)	2.70 (0.11)

Values are mean (SD) or n (%). Cognitive scores are z-standardized.

Figure 1. Brain structure-cognition associations by education



All MRI and cognition measures were z-standardized. Models adjusted for age, sex, intracranial volume, interview-to-MRI time interval, and the other MRI measures.

Table 2. Adjusted R² statistics by education status and cognitive domain

	No formal education (n=198)					
	General cognition	Memory	Executive function	Orientation	Language	Visuospatial
Model without covariates¹	0.062	0.003	0.061	0.095	0.013	0.011
Model with covariates²	0.125	0.052	0.106	0.102	0.071	0.083
	Any formal education (n=202)					
	General cognition	Memory	Executive function	Orientation	Language	Visuospatial
Model without covariates¹	0.022	0.002	0.061	0.069	0.0001	0.013
Model with covariates²	0.054	0.062	0.104	0.087	0.025	0.057

Values are adjusted R², the proportion of outcome variance explained within each education group. ¹ Model without covariates includes all five MRI measures simultaneously. ² Model with covariates additionally adjusts for age, sex, intracranial volume, and interview-to-MRI time interval.

RESULTS

- Associations between structural MRI markers and cognition were generally stronger among participants with no formal education.
- Total gray matter volume showed the clearest pattern: a 1-SD increase was associated with 0.49 SD higher general cognition (95% CI: 0.21, 0.78) with no education versus 0.19 SD (95% CI: -0.13, 0.50) with any education.
- In fully adjusted models including structural MRI measures and covariates, adjusted R² for general cognition was 0.125 among participants with no education and 0.054 among those with any education.
- Education interaction terms were not statistically significant, likely reflecting limited precision in the MRI sample.

DISCUSSION

- The direction and consistency of estimates are consistent with the cognitive reserve hypothesis in an Indian setting.
- Findings suggest that formal education may buffer the cognitive impact of brain structural atrophy among older adults in India.
- Strengths include culturally adapted HCAP assessment and harmonized multi-site T1 MRI; limitations include cross-sectional design and limited statistical power.

CONCLUSION

- Older adults in India without formal education may be more vulnerable to the cognitive impacts of brain structural atrophy than peers with formal education.

REFERENCES

- Stern Y. Cognitive reserve in ageing and Alzheimer’s disease. The Lancet Neurology. 2012;11(11):1006-1012. doi:10.1016/S1474-4422(12)70191-6
- Stern Y, Albert M, Barnes CA, Cabeza R, Pascual-Leone A, Rapp PR. A framework for concepts of reserve and resilience in aging. Neurobiology of Aging. 2023;124:100-103. doi:10.1016/j.neurobiolaging.2022.10.015
- Lee J, Meijer E, Langa KM, et al. Prevalence of dementia in India: National and state estimates from a nationwide study. Alzheimer’s & Dementia. 2023;19(7):2898-2912. doi:10.1002/alz.12928
- Langa KM, Ryan LH, McCammon RJ, et al. The Health and Retirement Study Harmonized Cognitive Assessment Protocol Project: Study Design and Methods. Neuroepidemiology. 2020;54(1):64-74. doi:10.1159/000503004

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