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The Association of Multilingualism With Diverse Language Families and Cognition Among Adults With and Without Education in India

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Objective: Early-life socioeconomic factors, such as education, closely associated with the opportunity to become multilingual (ML), are important determinants of late-life cognition. To study the cognitive advantage of multilingualism, it is critical to disentangle whether cognitive benefit is driven by multilingualism or education. With rich linguistic diversity across all socioeconomic gradients, India provides an excellent setting to examine the role of multilingualism on cognition among individuals with and without education. ***Method:*** Using data from the Longitudinal Aging Study in India—Diagnostic Assessment of Dementia, we evaluated the association of multilingualism by language similarity (i.e., speaking languages from the same or different language families) and education with cognition. Longitudinal Aging Study in India—Diagnostic Assessment of Dementia is a nationally representative sample of older Indian adults aged 60 and over, speaking 40 different languages and dialects ($N = 4,088$, 54% without formal schooling). Multilingual participants were categorized whether they spoke ≥2 languages within the same (classified as ML1) or different (classified as ML2) language families. Participants completed a comprehensive cognitive assessment assessing the domains of executive functioning, language, memory, and visuospatial ability. ***Results:*** Education stratified regression models adjusted for relevant covariates in the full sample and in a propensity-score matched sample. Among those with education, multilingualism was associated with better cognitive functioning across all domains regardless of language family (all p's < .05). Among those without education, only ML1 (not ML2) was associated with better executive functioning (B = 0.17 [0.07, 0.27]) compared to monolinguals. ***Conclusions:*** These findings add to the growing literature on cognitive advantage of multilingualism, disentangling them from education and suggesting differential effects by language similarity.

Key Points

Question: What is the effect of multilingualism on cognition among individuals with and without education in India? ***Findings:*** Multilingualism was associated with better cognitive performance across various domains, among individuals with and without formal schooling. ***Importance:*** Findings demonstrate potential for examining the relationship between multilingualism and cognition in large population-based cohort studies. ***Next Steps:*** Future measurement of the various attributes of language proficiency will help us understand with aspects of multilingualism may benefit late-life cognitive performance.

Keywords: bilingualism, multilingualism, cognitive advantage, cognitive aging, Indian population

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Data access can be requested and is accessible to the larger research community from the Gateway to Global Aging Data website at https://g2aging.org/.

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continued

While some studies find that multilingualism (i.e., speaking two or more languages) is associated with better cognitive performance compared to monolingual individuals (Bialystok, 2021; Green & Abutalebi, 2013), several other studies do not find differences in cognitive test performance (Paap et al., 2020; von Bastian et al., 2016). The primary challenge in examining the association between multilingualism and cognition is that many life-course socioeconomic factors are associated with the opportunity and/ability to become multilingual (ML), such as childhood and adulthood socioeconomic status (SES), educational attainment, among others (Bak, 2016), which in turn are associated with late-life cognitive health (Adkins-Jackson et al., 2023; Glymour & Manly, 2008). As such, it is difficult to disentangle whether the cognitive benefit is driven by multilingualism or by social factors such as education. To examine whether an effect of multilingualism on cognition is attributable to the confounding effects of education, a representative sample of multilingual adults with equivalent amounts of schooling would be required. Low- and middle-income countries such as India, with rich linguistic diversity across all socioeconomic gradients, may provide the ideal setting to examine the role of multilingualism on cognition among individuals with and without formal schooling.

It is important to note that evidence of cognitive benefits of being multilingual has been most commonly identified in the executive functioning domain (Adesope et al., 2010; Chen et al., 2022; Gunnerud et al., 2020), yet several studies also report a multilingual advantage in memory, visuospatial abilities, and aspects of language functioning (Luo et al., 2010; Rosselli et al., 2019; Wodniecka et al., 2010). However, as previously mentioned, various meta-analytic studies have not found consistent evidence of differences in cognition attributable to multilingualism (Paap et al., 2020), and when differences are found effect sizes are largely small and not distinguishable from zero after accounting for publication bias (Paap et al., 2024). Methodological differences regarding the operationalization of multilingualism, representativeness of study samples, and how socioeconomic confounds (e.g., education, childhood SES) are accounted for may explain discrepancies across these studies.

Multilinguals are generally treated as a monolithic group when in fact they demonstrate substantial within-group variability. A key factor in which multilinguals differ is on which languages they use. Most studies combine different language pairs within a multilingual group regardless of the linguistic similarity between the languages. For instance, recent studies included English–Spanish, English–Arabic, English–Armenian, English–French, and German–Italian bilinguals within the same bilingual sample (Ballarini et al., 2023; Bialystok et al., 2014; Gold et al., 2013; von Bastian et al., 2016). Speaking languages from different linguistic families (i.e., Germanic vs. Arabic) has been associated with differences in the structural connectivity of language networks (Wei et al., 2023). The demands of cross-language interference are a potential mechanism that may strengthen cognitive control among multilinguals, suggesting that more similar languages may be more prone to interference and thus provide more frequent opportunities to strengthen cognitive control (Oschwald et al., 2018). A few studies, which have relied on relatively small sample sizes, have attempted to evaluate the impact of language similarity (i.e., speaking languages within the same linguistic family vs. different families) on cognitive outcomes and have yielded mixed results (Barac & Bialystok, 2012; Bialystok et al., 2003, 2005; Coderre & van Heuven, 2014; Kirk et al., 2014; Linck et al., 2008; Runnqvist et al., 2013). A large representative sample of multilingual adults is needed to evaluate whether multilinguals who speak similar languages perform better on cognitive measures than multilinguals who speak dissimilar languages.

In this article, we aim to examine cognitive advantage of multilingualism, differentiating similarity of language families among individuals with and without formal schooling, using the Longitudinal Aging Study in India—Diagnostic Assessment of Dementia (LASI-DAD), a nationally representative study of late-life cognition and dementia in India (Lee et al., 2019). There are 22 scheduled languages in India, which are recognized as official languages, and 99 nonscheduled languages (Census of India, 2011). Each state has at least one official language, and many have two. This variety of languages is represented across five language families: Indo-Aryan,

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Dravidian, Austro-Asiatic, Tibeto-Burmese, and Andamanese. Moreover, in addition to these Indian languages, non-Indian language families such as Indo-European (i.e., English) and Japonic (i.e., Japanese), among others, have been increasing in prevalence in India as well.

With the unique context of robust linguistic diversity in LASI-DAD, the primary goals of the present study are to (a) evaluate whether multilingualism in the same or different language families is associated with cognitive performance across various domains (executive functioning, memory, language, and visuospatial abilities); and (b) to disentangle the confounding influence of education. We evaluate the association between multilingualism and cognition among individuals with and without any formal schooling. We hypothesized that multilinguals within the same language family would demonstrate better cognitive performance than all other groups due to the higher demands of managing language interference, and this association would be observed among both multilinguals with and without education.

Method

Data analysis was conducted on the Harmonized LASI-DAD Wave 1 Version A.3 available on request from the Gateway to Global Aging website at https://g2aging.org/. Details about the LASI-DAD study are published elsewhere (Lee et al., 2019). In brief, LASI-DAD is a subsample of adults aged 60 and older from the Longitudinal Aging Study in India (LASI), a nationwide panel survey of adults ages 45 and older and their spouses regardless of age (total $N > 73,000$), representing both the country as a whole and each state and union territory in India. For LASI-DAD, a two-stage stratified sampling approach was employed, oversampling individuals at high risk of cognitive impairment to ensure a sufficient number of participants with dementia and mild cognitive impairment. The LASI-DAD used the Health and Retirement Study's Harmonized Cognitive Assessment Protocol, which was validated within the country before being implemented in the study (Banerjee et al., 2020). Necessary modifications were made to ensure cultural and linguistic appropriateness. The HCAP battery was translated into 12 local languages: Hindi, Kannada, Malayalam, Gujarati, Tamil, Punjabi, Urdu, Bengali, Assamese, Odiya, Marathi, and Telugu. The study visit was carried out in the participant's preferred language. The preferred language of testing was their mother tongue among 67% of the multilingual participants. To facilitate accurate assessment due to the linguistic diversity inherent in India, all LASI-DAD examiners were recruited from each state and were multilingual in the local languages. The present sample comprises 4,088 adults across 18 states and union territories. Eight participants were excluded due to missing language data.

The research was completed in accordance with the Helsinki Declaration. The study was reviewed and approved by the University of Southern California's Institutional Review Board, the Indian Council of Medical Research, and all collaborating institutes in India, including the following: All India Institute of Medical Sciences, New Delhi; All India Institute of Medical Sciences, Bhubaneswar; D Sampurnanand Medical College, Jodhpur; Government Medical College, Thiruvananthapuram; Government Medical College, Chandigarh, Punjab; Grants Medical College and JJ Hospital, Mumbai; Guwahati Medical College, Guwahati; Institute of Medical Sciences, Banaras Hindu University, Varanasi; Indira Gandhi Institute of Medical Sciences, Patna, Bihar; Institute of Medical Sciences, Banaras Hindu University, Varanasi; Madras Medical College, Chennai; Medical College, Kolkata; National Institute of Mental Health and Neurosciences, Bengaluru; Nizam's Institute of Medical Sciences, Hyderabad; Sher-e-Kashmir Institute of Medical Sciences, Srinagar; and St. John's Medical College, Bengaluru.

Multilingualism and Language Families

Multilingualism status was operationalized based on two questions that were asked during the main LASI study. Participants were first asked "What is your mother tongue?" followed by "What other languages do you speak," which allowed for multiple answers. Languages were classified into the following language families based on the 2011 Indian Census classifications (Census of India, 2011): Dravidian, Indo-Aryan, Tibeto-Burmese, Austro-Asiatic, Semito-Hamitic, Japonic, and Germanic (see Supplemental Table S1). Multilingual participants were grouped based on whether they spoke two or more languages within one language family (ML1) or across two or more language families (ML2). Given the rich linguistic diversity in India, around 25% of our sample reported speaking three or more languages. For participants that reported speaking three or more languages, they were classified as ML2 if one or more languages were from a different language family. Participants were classified as monolingual if they reported speaking only one language (i.e., their mother tongue).

Cognition

LASI-DAD administers a comprehensive neuropsychological battery that was adapted from the Health and Retirement Study-Harmonized Cognitive Assessment Protocol to be appropriate for the Indian context and to allow for cross-country comparisons. Cognitive domain factor scores were estimated through confirmatory factor analysis. Neuropsychological tests were grouped into four cognitive domains: memory, executive functioning, language, and visuospatial functioning. The resulting factor scores are standardized with a mean of 0 and a standard deviation of 1. Prior work has determined the cognitive factor structure of the battery demonstrated good fit (root-mean-square error of approximation = 0.051; comparative fit index = 0.916; standardized root-mean-squared residual = 0.060) and has demonstrated configural factorial invariance (Gross et al., 2020). Cognitive tests representing each domain are detailed in Table 1 and Supplemental Table S2. Previous work has demonstrated comparable measurement across the study languages (Gross et al., 2020).

Socioeconomic and Health Covariates

The following variables were used as covariates in the analysis to account for socioeconomic and health characteristics that may confound the association of multilingualism with cognition. These variables were collected at either the LASI-DAD or LASI visit. The participant's age at time of interview was derived from the LASI-DAD interview month and year and the participant's birth month and year. The number of years of schooling received, as reported by the participant, was used to categorize participants as having received no formal schooling (zero years) or some formal schooling (1 or more years). Given that no schooling is common among older adults in India (50% literacy rate per Indian Census) and 49% of our

Table 1
Longitudinal Aging Study in India—Diagnostic Assessment of Dementia Cognitive Battery

Domain	Test
Orientation	Orientation to time and place (HMSE)
Memory	Word learning and recall
	Ten-word recognition
	Logical Memory
	Logical Memory Recognition
	Constructional Praxis Recall
Executive functioning	Raven's test
	Go/No-Go test
	Serial 7's
	Backward Day Naming (from HMSE)
	Symbol cancelation
	Digit span forward and backward
Language	Retrieval fluency
	Object naming from HMSE)
	Writing or saying a sentence (from HMSE)
	Reading or repeating a sentence (from HMSE)
	Paper-folding three-step task (from HMSE)
Visuospatial	Constructional Praxis
	Interlocking pentagons (from HMSE)

Note. HMSE = Hindi Mental State Exam.

sample reported no formal schooling, we chose to categorize participants as having received no formal schooling (zero years) or some formal schooling (1 or more years) based on the self-reported number of years of schooling received. Urbanicity indicates whether the participant lived in an urban community or rural village at the time of their interview and was defined according to the 2011 Census. Consumption is a measure of the use of goods and services by households. Consumption quartile was calculated based on the total household consumption, which is an aggregate of all consumption activities, including food consumption in the last week, nonfood in the last 30 days, other nonfood consumption in the past year, outpatient health care expenditures in the past 30 days, and inpatient health care expenditures in the past year. These consumption activities were first scaled to the same periodicity (year), aggregated, and then divided by the number of people in the household. Body mass index (BMI) is calculated by dividing the participant's weight (kg) by the square of his/her height (m). We assigned participants into four categories: underweight (BMI < 18.5), healthy weight ($18.5 \leq$ BMI < 25), overweight ($25 \leq$ BMI < 30), and obese (BMI ≥ 30). Medical history was based on self-report of whether a health professional diagnosed them with the following conditions: hypertension, diabetes, and heart disease. Smoking status indicates whether the participant reported ever smoking tobacco and includes a cigarette, bidi, cigar, hooka, or cheroot. Hearing impairment was based on self-reported hearing loss.

Weights

LASI-DAD sample weights are meant to account for differential selection probabilities produced by the adopted sampling strategy, and to adjust for differential nonresponse across sampled individuals. They align the LASI-DAD sample distributions of basic demographics (gender, age, literacy, and urbanicity) to the corresponding distributions in the Indian population aged 60 and older. Details about the construction of the weights can be found in the Harmonized LASI-DAD Codebook available in the Gateway to Global Aging website at https://g2aging.org/ (Chien et al., 2021). The full sample analyses used sampling weights to ensure our estimates are nationally representative and remove the influence of the sampling strategy (i.e., oversampling individuals at risk for cognitive impairment) on our outcomes.

Analytic Plan

All analyses were conducted in R 4.3.1. Descriptive characteristics were calculated for the total sample, the group with formal schooling, and the group with no formal schooling. One-way analysis of variance was used to determine whether there were any statistically significant differences in demographic characteristics (age, sex/gender, years of education, urbanicity) between the three language groups (monolingual, ML1 [multilingual: one language family], ML2 [multilingual: 2+ language families]). Pairwise comparisons of means and chi-square tests were conducted to compare differences in demographic characteristics between each language group pairing.

Independent general linear models evaluated the association between language group and each cognitive domain (executive functioning, memory, language, visuospatial). All models were stratified by education (some schooling vs. no formal schooling) and adjusted for age, sex/gender, urbanicity, BMI, hypertension, diabetes, heart disease, smoking status, hearing loss, consumption quartile, and childhood SES (i.e., parental education). In the analyses among the sample with some schooling we also adjusted for years of education.

To address concerns of inadequate control of confounding, we conducted a sensitivity analysis using propensity-score matching. Statistically controlling for relevant confounds may be inappropriate given that some of these group differences may be nontrivial and systematic (e.g., greater proportion of women and individuals with lower educational attainment among monolinguals), leading to nonoverlap in the distributions of confounders across groups and potentially spurious results (Miller & Chapman, 2001). Thus, we used propensity-score matching to ensure adequate balance on confounders of interest. Propensity matched scores were created based on all the aforementioned covariates, and the independent general linear models were repeated, including covariates, using the propensity matched samples. The propensity scores were estimated separately for the schooling and the no formal schooling subsamples using logistic regressions, applying one-to-one nearest neighbor matching without replacement.

Within the "some schooling" group, there were statistically significant differences among the multilingual groups, thus a two-step propensity matching approach was used, first matching the ML2 group to the ML1 group. To achieve good balance, a distance metric was applied (caliper width 0.1), which resulted in matching 223 individuals from the ML2 group to members of the ML1 group (i.e., 136 ML2 participants were not matched). To minimize differences between mono- and multilingual people, we then matched the multilingual groups separately to the to the monolingual participants. All multilingual participants (n = 446; 223 ML2 and 223 ML1 participants) were matched to a monolingual participant (n = 446). However, because we matched both multilingual groups separately to the monolingual group, 95 monolingual participants were matched twice (i.e., the total number of observations was 892). These 95 monolingual individuals were weighed twice during the linear models to adjust for duplicates. The propensity matched sample within the schooling group included 797 adults (50% monolingual, 25% ML1, 25% ML2). Good balance was achieved in both matches, with all standardized mean differences below 0.12 postmatching.

When conducting the propensity-score matching within the no formal schooling group, there were no statistically significant differences among the multilingual groups (ML1, ML2). Thus, they were grouped and matched to the monolingual participants. All multilingual participants ($n = 331$) were matched to a monolingual participant. The propensity-score matched sample within the no formal schooling group included 662 adults (50% monolingual, 39% ML1, 11% ML2). Good balance was achieved, with all standardized mean differences below 0.13 postmatching.

Data Usage and Availability Statement

Ethics approval was obtained by the University of Southern California Institutional Review Board (UP15-00684) and the Indian Council of Medical Research for the All India Institute of Medical Science (54/01/Indo-foreign/Ger/16-NCD-II). Data access can be requested and is accessible to the larger research community from the Gateway to Global Aging Data website at https://g2aging.org/.

Results

The full analytic sample included 4,088 adults (Table 2) of which 74% were monolingual, 17% were multilingual in one language family, and 9% were multilingual in 2+ language families. Multilingual participants reported speaking a range of two to eight languages (75% two languages, 19% three languages, 6% four or more languages). As shown in Table 2, there were significant differences in age, years of education, sex, urbanicity, and consumption between monolingual and the multilingual groups overall. The monolingual group was older, with lower educational attainment, and had a greater proportion of women than both multilingual groups. The monolingual and ML1 group were more likely to reside in rural areas and have lower consumption than the ML2 group (Figure 1).

Among participants with formal schooling (Table 3), there were no significant differences in age between the language groups. There was a greater proportion of women, individuals residing in rural areas, and with lower consumption in the monolingual group, followed by the ML1 group, with the ML2 group having the least number of women, individuals residing in rural areas, and with lower consumption. Groups differed in years of schooling, with monolinguals having the lowest educational attainment, followed by the ML1 group, and the ML2 group having the highest levels of education. Among participants with no formal schooling (Table 3), there were no statistically significant differences in age or sex/gender between the language groups. However, there was a higher proportion of monolingual participants residing in rural areas compared to the ML1 and ML2 groups. In the propensity-score matched groups, after matching, there were no statistically significant differences remaining in the covariates among multilinguals, nor between multilingual and monolingual participants in both education groups.

Multilingualism and Cognition Among Those With Some Schooling

Full Sample

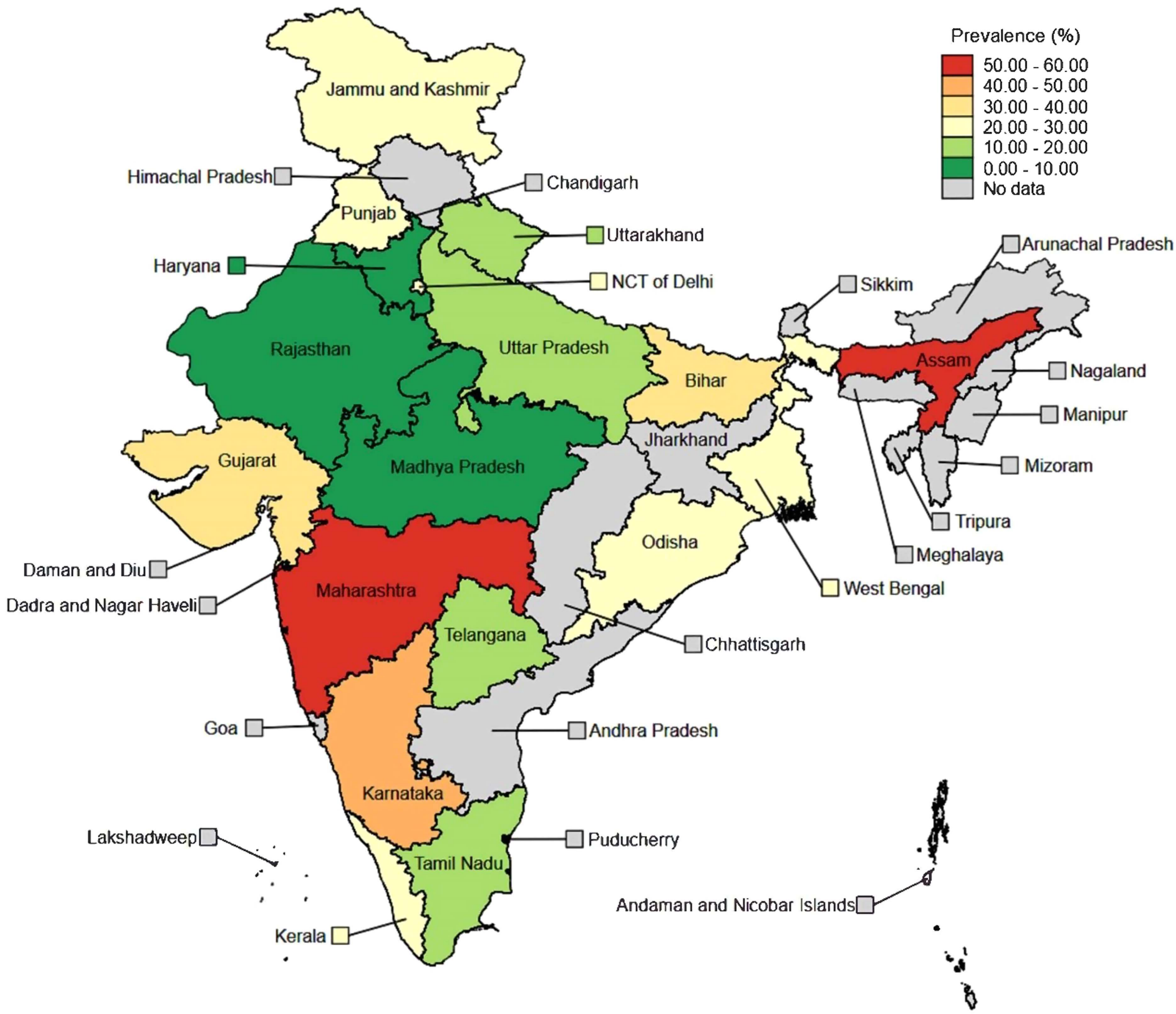
Among participants with formal schooling, cognitive factor scores were significantly higher for the ML1 group than for the monolinguals after controlling for all covariates in all cognitive domains: executive function (β = 0.231, 95% CI [0.157, 0.327]), memory (β = 0.240, 95% CI [0.148, 0.331), visuospatial (β = 0.244, 95% CI [0.147, 0.340]), language (β = 0.114, 95% CI [0.016, 0.211]). A similar pattern was observed when comparing the ML2 group to monolinguals: executive function (β = 0.231, 95% CI [021, 0.342]), memory (β = 0.260, 95% CI [0.141, 0.379]), and visuospatial (β = 0.169, 95% CI [0.043, 0.296]), language (β = 0.179, 95% CI [0.052, 0.307]). There were no

Table 2
Demographic Distribution of Study Sample

Demographic	Monolingual		Multilingual (one language family)		Multilingual (2 + language families)		
Demographic	*N*	*M*	*N*	*M*	*N*	*M*	*p*[a]
Age	2,902	69.81	755	68.97	431	69.08	.01
Years of education	2,902	2.42	755	4.51	431	8.78	<.001
Demographic	*N*	%	*N*	%	*N*	%	*p*[a]
Gender							
Male	1,200	44	406	58	280	68	<.001
Female	1,702	55	349	42	151	32	
Urbanicity							
Urban	863	23	393	42	302	61	<.001
Rural	2039	77	362	58	129	39	
Consumption							<.001
Q1	826	29	153	20	43	10	
Q2	764	26	196	26	62	14	
Q3	695	24	217	29	110	26	
Q4	617	21	189	25	216	50	

Note. Data are weighted. Q = quartile; ANOVA = analysis of variance.
[a] One Way ANOVA test of differences between monolingual and multilingual groups.

Figure 1
Prevalence of Multilingualism in the Longitudinal Aging Study in India—Diagnostic Assessment of Dementia Study



Note. NCT = National Capital Territory. See the online article for the color version of this figure.

statistically significant differences between the two multilingual groups on all cognitive domain factor scores (see Figure 2 and Table 4).

Propensity Sample

The results of the propensity-score matched sample generally aligned with the results of the full sample. Among individuals with schooling, the ML1 group outperformed the monolingual group in executive function (β = 0.196, 95% CI [0.044, 0.347]), memory (β = 0.173, 95% CI [0.019, 0.327]), but not within language (β = 0.047, 95% CI [−0.117, 0.210]), nor the visuospatial domain (β = 0.125, 95% CI [−0.038, 0.288]) which were the only two differences with the full sample analysis. Akin to the full sample analysis, the ML2 group outperformed the monolingual group in executive function (β = 0.284, 95% CI [0.132, 0.436)], language (β = 0.209, 95% CI [0.046, 0.372]), memory (β = 0.226, 95% CI [0.072, 0.380]), but not within the visuospatial domain (β = 0.106, 95% CI [−0.057, 0.269]), which was the only difference with the full sample analysis. Similar to the full sample analysis, no differences were observed between the multilingual groups in any of the cognitive domains (see Supplemental Table S3).

Multilingualism and Cognition Among Those Without Schooling

Full Sample

Among participants with no formal schooling, compared to monolingual participants, the ML1 group had higher scores on

Table 3
Demographic Distribution of Study Sample by Education

	Monolingual		Multilingual (one language family)		Multilingual (2 + language families)		
Demographic	*N*	*M*	*N*	*M*	*N*	*M*	p^a
			Any education				
Age	1,228	69.14	496	68.53	359	68.92	.20
Years of education	1,228	6.37	496	7.34	359	11.09	<.001
Demographic	*N*	%	*N*	%	*N*	%	p^a
Gender							
Male	710	62	326	71	255	75	<.001
Female	518	38	170	29	104	25	
Urbanicity							
Urban	469	30	280	47	268	68	<.001
Rural	759	70	216	55	91	32	
Consumption							<.001
Q1	266	22	71	14	21	6	
Q2	325	26	124	25	47	13	
Q3	317	26	151	30	89	25	
Q4	320	26	150	30	202	56	
Demographic	*N*	*M*	*N*	*M*	*N*	*M*	p^a
			No education				
Age	1,674	70.21	259	69.67	72	69.68	.58
Demographic	*N*	%	*N*	%	*N*	%	p^a
Gender							
Male	490	34	80	37	25	42	.55
Female	1,184	66	179	63	47	58	
Urbanicity							
Urban	394	18	113	34	34	38	<.001
Rural	1,280	82	146	66	38	62	
Consumption							.61
Q1	560	34	82	32	22	31	
Q2	439	26	72	28	15	21	
Q3	378	23	66	26	21	29	
Q4	297	18	39	15	14	19	

Note. Data are weighted. Q = quartile; ANOVA = analysis of variance.
[a] One way ANOVA test of differences between monolingual and multilingual groups.

executive function (β = 0.260, 95% CI [0.136, 0.383]), and visuospatial ability (β = 0.140, 95% CI [0.009, 0.270]), but not on memory (β = 0.105, 95% CI [−0.022, 0.232]) and language (β = 0.067, 95% CI [−0.064, 0.197]). The ML2 group did not differ from the monolingual and ML1 participants on any cognitive domain (see Figure 3 and Table 5).

Propensity Sample

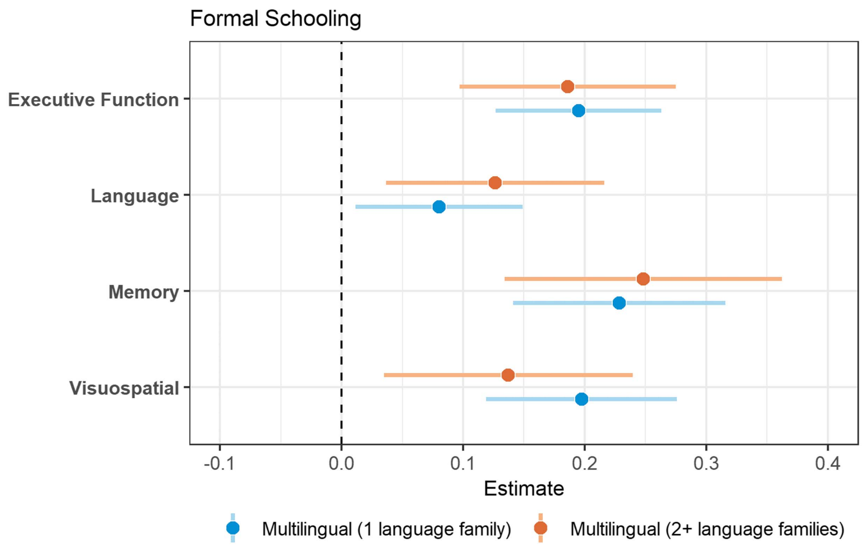
Among individuals without schooling, the propensity matched analyses were similar to the findings of the full sample. Compared to the monolingual participants, the cognitive factor scores from the ML1 group were significantly higher in executive function (β = 0.249, 95% [0.099, 0.398]), but not in language (β = 0.149, 95% [−0.008, 0.305]), memory (β = 0.083, 95% [−0.071, 0.237]), or the visuospatial domain (β = 0.136, 95% [−.021, 0.292]); which was the only difference with full sample analysis. The ML2 group did not differ from the monolingual, nor the ML1 groups in any cognitive domain (see Supplemental Table S4).

Discussion

Using a nationally representative sample of older adults in India, the present study showed that multilingualism was associated with better cognitive performance across various domains, among individuals with and without formal schooling. We also evaluated an aspect of multilingualism rarely studied, the role of language families on cognitive test performance. We hypothesized that due to the potential greater interference between languages, multilinguals that spoke languages within the same language family would outperform multilinguals that used languages from different linguistic families. Our hypothesis was partly supported. Among older adults with no formal schooling, same language family multilinguals performed better on executive functioning than monolinguals but did

Figure 2

Association of Multilingual Status and Cognitive Functioning Among Participants With Education



Note. All models control for: age, sex, years of education, education, urbanicity, BMI, hypertension, diabetes, heart disease, smoking status, hearing loss, consumption quartile, and childhood socioeconomic status (parental education). BMI = body mass index. See the online article for the color version of this figure.

not reliably differ from multilinguals that use different language families. Among older adults with any schooling, multilinguals performed better than monolinguals across all domains, regardless of language family.

While some studies have reported that older multilinguals outperform older monolinguals in tasks of executive functioning, episodic memory, and visuospatial abilities (Bialystok et al., 2014; Calvo & Bialystok, 2014; Chan et al., 2020; Costa et al., 2008; Luo et al., 2010; Rosselli et al., 2019; Wodniecka et al., 2010), several other studies do not (Gathercole et al., 2014; Kirk et al., 2014; Kousaie & Phillips, 2012; Morton & Harper, 2007; von Bastian et al., 2016). A common limitation of these past studies is that they have relied on relatively small sample sizes (Paap et al., 2015) which increases the possibility that results are biased by socioeconomic factors such as education (Watson et al., 2016). To date, the few studies that have used large population-based samples to evaluate whether multilingualism was associated with cognitive functioning did not find evidence for a cognitive advantage in either adulthood

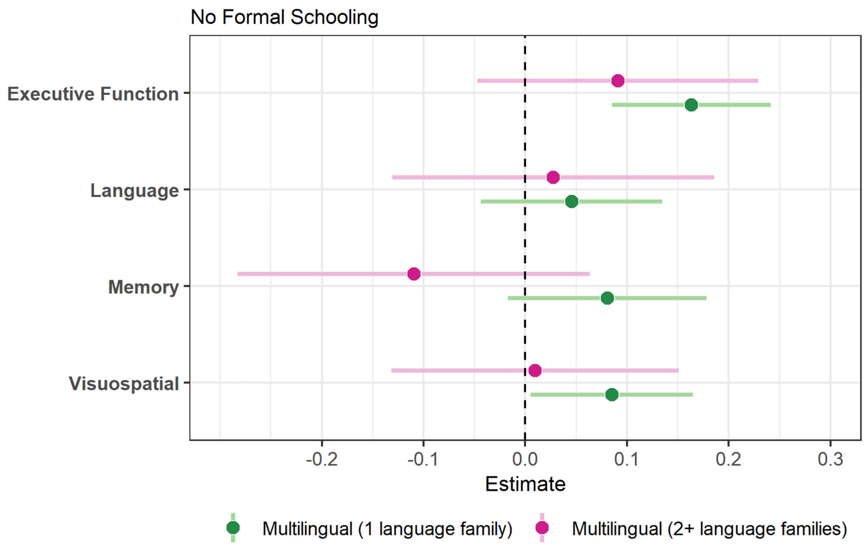
Table 4

Association of Multilingual Status and Cognitive Functioning Among Participants With Education; Full Analysis

Variable	Executive function		Language		Memory		Visuospatial	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Language group (ref: Monolingual)								
Multilingual (one language family)	0.242***	0.043	0.114*	0.050	0.240***	0.047	0.244***	0.049
Multilingual (2+ language family)	0.231***	0.056	0.179**	0.065	0.260***	0.061	0.169**	0.064
Years of education	0.395***	0.022	0.309***	0.025	0.263***	0.023	0.307***	0.025
Age (years)	−0.191***	0.018	−0.144***	0.021	−0.216***	0.020	−0.168***	0.021
Sex (ref: Male)								
Female	−0.291***	0.044	−0.025	0.050	0.182***	0.047	−0.221***	0.050
Rurality (ref: Urban)								
Rural	−0.221***	0.039	−0.082	0.045	−0.127**	0.042	−0.016	0.045
Consumption (ref. Quartile 1)								
Quartile 2	0.060	0.054	0.015	0.062	0.012	0.058	0.110	0.062
Quartile 3	0.052	0.054	0.053	0.062	0.016	0.058	0.066	0.062
Quartile 4	0.064	0.054	0.038	0.062	0.061	0.059	0.021	0.062
Adj R^2	0.376		0.189		0.253		0.189	
Observations	2,083		2,083		2,083		2,083	

Note. All models control for age, sex, years of education, urbanicity, BMI, hypertension, diabetes, heart disease, smoking status, hearing loss, consumption quartile, and childhood socioeconomic status (parental education). *SE* = standard error; ref. = reference; BMI = body mass index.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Figure 3
Association of Multilingual Status and Cognitive Functioning Among Participants With No Education



Note. All models control for: age, sex, education, urbanicity, BMI, hypertension, diabetes, heart disease, smoking status, hearing loss, consumption quartile, and childhood socioeconomic status (parental education). BMI = body mass index. See the online article for the color version of this figure.

(Nichols et al., 2020) or childhood (Dick et al., 2019). Although Nichols et al. (2020) did not find any evidence for a bilingual cognitive advantage among a sample of 11,000 adults, their participants were largely younger (i.e., the bilingual group was on average 35 years old) and cognitive tests were completed online. Requiring that participants be evaluated through online measures can introduce a socioeconomic selection bias (i.e., access to computers and adequate internet connection, familiarity with computers) that may limit the generalizability of their results. In addition, both the Nichols et al. (2020) and Dick et al. (2019) studies may have been limited by focusing on cognition at earlier life stages (i.e., childhood, middle-age), whereas our study extends these findings to study cognition in late-life when brain health is more likely to be impacted by neurodegenerative process. By leveraging a nationally representative sample of well-characterized older Indian adults in the LASI-DAD study, we were able to increase the generalizability of prior studies to multilingual and monolingual adults residing in India. In addition, rather than relying on experimental and/or computerized tasks, we utilized a comprehensive neuropsychological assessment that has shown adequate measurement among the older Indian population

Table 5
Association of Multilingual Status on Cognitive Functioning Among Participants With No Education; Full Analysis

	Executive function		Language		Memory		Visuospatial	
Variable	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Language group (ref: Monolingual)								
Multilingual (one language family)	0.260***	0.063	0.067	0.066	0.105	0.065	0.140*	0.067
Multilingual (2+ language family)	0.145	0.112	0.040	0.118	−0.142	0.115	0.016	0.118
Age (years)	−0.205***	0.021	−0.165***	0.023	−0.215***	0.022	−0.207***	0.023
Sex (ref: Male)								
Female	−0.490***	0.048	−0.237***	0.051	−0.092	0.049	−0.325***	0.051
Rurality (ref: Urban)								
Rural	−0.232***	0.053	−0.166**	0.055	−0.213***	0.054	−0.013	0.055
Consumption (ref. Quartile 1)								
Quartile 2	0.138	0.054	0.011	0.056	0.065	0.055	0.042	0.056
Quartile 3	0.079	0.056	0.025	0.059	0.127	0.057	0.069	0.059
Quartile 4	0.211	0.062	0.092	0.065	0.227	0.063	0.166	0.065
Adj R^2	0.155		0.065		0.114		0.070	
Observations	2,005		2,005		2,005		2,005	

Note. All models control for age, sex, urbanicity, BMI, hypertension, diabetes, heart disease, smoking status, hearing loss, consumption quartile, and childhood socioeconomic status (parental education). *SE* = standard error; ref. = reference; BMI = body mass index.
* $p < .05$. ** $p < .01$. *** $p < .001$.

across different languages and educational backgrounds (Gross et al., 2020). Moreover, to further account for the unequal distribution of confounders across the language groups, we leveraged the large sample size to develop a propensity-score matched sample and our results remained largely unchanged. Among our population-based sample of older Indian adults, multilingualism was associated with better cognitive test performance across various domains after adjusting for relevant socioeconomic and health factors, and even in our propensity-score matched sample.

The association of multilingualism with cognition differed between those with and without education. Among those with some schooling, we saw that multilingualism was associated with better performance in executive functioning and memory, as well as, but less reliably, with language and visuospatial abilities. However, the association with cognitive functioning among those without formal schooling was limited. First, among those with no formal schooling, there was a positive association of multilingualism with both executive functioning and visuospatial abilities. In our propensity-score matched analytic approach, the significant association with executive functioning was consistent. The association with visuospatial abilities had a similar point estimate, but did not retain statistical significance, likely due to the reduced sample size in the matched analysis. It should be noted that despite differences in statistical significance across the analytic approaches, most of the associations remained positive across all domains. Our results suggest that multilingualism may provide some benefit to cognition among multilingual adults without any formal schooling, especially when the languages spoken are from the same language family.

Individuals with little to no educational opportunities are more likely to face greater socioeconomic and environmental challenges throughout the life-course that can have deleterious effects on late-life cognitive health (i.e., illiteracy, lower SES, stressors; Glymour & Manly, 2008). It may be that multilingualism cannot fully compete against the detrimental effects of cumulative exposure of a disadvantaged environment. To date, there has been one study among older Indian adults that reported a greater benefit of multilingualism on cognitive outcomes, such as a later age of dementia onset, specifically among illiterate Indian adults when compared to illiterate monolingual Indian adults (Alladi et al., 2013). Although the Alladi et al.'s (2013) study looked at different outcomes than ours (i.e., dementia onset vs. cross-sectional cognitive functioning), additional differences between the cohorts may account for discrepancies between findings. Participants in Alladi et al. (2013) were recruited exclusively from a memory clinic in a major urban city (Hyderabad), which can be a source of selection bias (Rodríguez-Gómez et al., 2015). Future studies should investigate whether multilingualism modifies the negative impact of illiteracy on late-life cognitive outcomes among more representative samples of adults with limited formal schooling. Similarly, future studies should further characterize the association between multilingualism and education to understand whether this cognitive advantage is equally present across different levels of educational attainment beyond those examined in the present study (i.e., primary, secondary, college education, etc.).

An additional contribution of our study is that we evaluated an aspect of multilingualism hypothesized to impact cognition: the role of language similarity/dissimilarity. Current literature on the effect of language similarity on cognitive function is mixed. While some studies find bilinguals who speak similar languages outperform monolinguals on executive functioning tasks (Bialystok et al., 2003, 2005; Runnqvist et al., 2013), other studies fail to find such evidence (Coderre & van Heuven, 2014; Kirk et al., 2014; Linck et al., 2008). In our sample of older adults, among those with schooling, a multilingual cognitive advantage was seen regardless of whether the languages were similar (one language family) or dissimilar (two or more language families).

However, among older adults with no education, a multilingual benefit was only found among those who spoke more similar languages specifically in executive functioning. There may be a few explanations for this finding. First, languages spoken within one language family in India are geographically closer to one another, as compared to languages in different language families, which can result in an increased opportunity to use these multiple languages on a regular basis. For instance, languages in South India have grammatical structures and scripts with Dravidian roots, and languages in the Central and Northern regions of India are part of the Indo-Aryan family of languages (Chandras, 2020). This can result in an increased opportunity to speak and be exposed to multiple languages on a regular basis if a person speaks languages within one language family. Multilingualism is hypothesized to provide a benefit to cognition through activating, suppressing, and jointly engaging in their known languages throughout a person's life which can strengthen attentional and executive networks to enhance cognitive processes through this bilingual language control (Bialystok, 2021; Bialystok et al., 2014). Thus, multilinguals using languages from the same family, which are more prevalent in their region, may frequently engage these attentional and inhibitory processes, leading to a stronger benefit to cognition compared to multilinguals from different language families. However, given that we currently do not have information on frequency of language use between our multilingual groups, future work will be required to directly evaluate whether these findings are related to objective differences in current usage of languages.

A limitation of the present study is that it did not include a comprehensive assessment of linguistic history with which to deconstruct multilingualism. Although this limitation is common in studies of multilingualism (Valian, 2015), multilinguals do differ in key linguistic characteristics (i.e., age of acquisition, degree of proficiency, frequency of language use). Several studies have found positive relationships between language proficiency and cognitive performance, suggesting greater cognitive benefits among high-proficiency bilinguals (Mohamed Zied et al., 2004; Singh & Mishra, 2012; Tse & Altarriba, 2012). In addition to proficiency, ascertaining frequency of language use would allow us to understand the potential linguistic mechanisms through which multilingualism influences cognition. Given the linguistic diversity in India, both within and between states (Census of India, 2011; Chandras, 2020), it is reasonable to assume some regularity of use of multiple languages in everyday life. However, as stated above, there may differences in the degree of language use between our multilingual groups (i.e., same vs. different language family multilingual) which may have an impact on cognition, in particular among those with no formal schooling. For instance, Calabria et al. (2020) found that active bilingualism, defined as a high proficiency in both languages with a balanced usage of those languages, significantly predicted delay in the age of onset of mild cognitive impairment. More comprehensive measures of language proficiency offer the opportunity to study multilingualism on a continuum, rather than grouping individuals into strict categories of monolingual or multilingual. Future measurement of these factors will help us understand which aspects of multilingualism may benefit late-life cognitive performance. Another limitation is the cross-sectional nature of this study, as it raises the issue of temporality. There is a need to conduct longitudinal studies to evaluate whether multilingualism is associated with change in cognition over time. Lastly, while a strength of our study was the inclusion of nationally representative weights and propensity-score matching with covariate adjustment for life-course factors to account for various sources of confounding, we cannot completely rule out the potential influence of unmeasured confounders. Given that multilingualism is a socially and culturally dependent experience with diverse determinants across cultural contexts, future studies should evaluate how factors such as caste, religion, and changes in the historical political context are associated with multilingualism and late-life cognitive health in India.

Nonetheless, this study, capitalizing on data from the LASI-DAD study, demonstrates the potential for examining the relationship between multilingualism and cognition in large population-based cohort studies. With the ability to control for potential life-course confounding factors such as education, urbanicity, health, and consumption, this study offers additional insights to the potential cognitive benefits of speaking two or more languages. India has an exceptionally rich linguistic diversity, with over 40 languages reported in our study representing seven different language families, which allowed us to distinguish multilinguals into those who speak similar and dissimilar languages. Furthermore, over half of our study sample had not received any formal schooling, allowing us to evaluate the association between multilingualism and cognition among those with no formal schooling. Given these study features, our findings provide unique insights into the association between multilingualism and cognitive health in older adults and lay the foundation for future work focused on late-life cognitive health among individuals residing in low- and middle-income countries.

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