Original Contribution

Longitudinal Associations of US Acculturation With Cognitive Performance, Cognitive Impairment, and Dementia

The Sacramento Area Latino Study on Aging

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US Latinos, a growing, aging population, are disproportionately burdened by cognitive decline and dementia. Identification of modifiable risk factors is needed for interventions aimed at reducing risk. Broad sociocultural context may illuminate complex etiology among culturally diverse Latinos. Among 1,418 older (≥60 years), low–socioeconomic position (SEP) Latinos (predominantly of Mexican descent) in Sacramento, California, we examined whether US acculturation was associated with cognitive performance, cognitive decline, and dementia/cognitive impairment without dementia over a 10-year period and whether education modified the associations (Sacramento Area Latino Study on Aging, 1998–2008). Analyses used linear mixed models, competing-risk regression, and inverse probability of censoring weights for attrition. Participants with high US acculturation had better cognitive performance (0.21 fewer cognitive errors at grand-mean-centered age 70 years) than those with low acculturation after adjustment for sociodemographic factors, practice effects, and survey language. Results may have been driven by cultural language use rather than identity factors (e.g., ethnic identity, interactions). Rate of cognitive decline and risk of dementia/cognitive impairment without dementia did not differ by acculturation, regardless of education (β = 0.00 (standard error, 0.00) and hazard ratio = 0.81 (95% confidence interval: 0.49, 1.35), respectively). High US acculturation was associated with better cognitive performance among these older, low-SEP Latinos. Acculturation may benefit cognition when SEP is low. Future studies should incorporate extended longitudinal assessments among more diverse groups.

acculturation; cognition; cognitive dysfunction; dementia; education; Hispanic Americans; social determinants of health

Abbreviations: ARSMA-II, Acculturation Rating Scale for Mexican Americans–Version II; CI, confidence interval; CIND, cognitive impairment, no dementia; HR, hazard ratio; IPCW, inverse probability of censoring weights; IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; 3MSE, Modified Mini-Mental State Examination; SALSA, Sacramento Area Latino Study on Aging; SE, standard error; SENAS, Spanish and English Neuropsychological Assessment Scales; SEP, socioeconomic position; SEVLT, Spanish English Verbal Learning Test.

Latinos are 1.5 times as likely to have Alzheimer disease and related dementias as non-Hispanic Whites, and are twice as likely to have cognitive impairment ([1–4]). However, cognitive outcomes vary among Latino subgroups ([5, 6]): For example, the odds of cognitive impairment among Mexican Americans are 2–5 times those among non-Hispanic Whites ([7, 8]). US Latinos are disproportionately burdened by modifiable socioeconomic and health-related dementia risk factors (e.g., low educational level, diabetes), which are shaped by broad social determinants like acculturation ([6, 9]).

Acculturation is cultural change after exposure to culturally dissimilar people, groups, and social influences; culture is comprised of language, attitudes, beliefs, behaviors, and interactions ([10]). Nativity initiates the acculturation process,

and longer duration of residence in a new country and common language use create opportunities for greater cultural exposure and community integration (10, 11). Importantly, these factors are sometimes treated as proxies for acculturation, but individually they do not capture the full acculturative process or its downstream health pathways (10).

Acculturation shapes health via social and behavioral pathways like daily activities, dietary choices, and healthcare access (9). Negative acculturation theory posits that US acculturation worsens health, but positive associations are also known (9, 12, 13). For example, high US acculturation is associated with increased alcohol consumption and smoking and a poorer diet, but also with greater healthcare access, economic and educational opportunities, and exercise (12–14). Understanding the relationship between acculturation and cognition may provide greater insight into risk differentials among US Latinos, and broad cultural links may guide intervention efforts aimed at identifying modifiable targets.

Research examining associations between acculturation proxies and cognitive outcomes has produced inconsistent results (7, 15–20). Still, 2 longitudinal studies carried out among Mexican Americans identified a higher risk of cognitive impairment among foreign-born participants than the US-born (16, 17) and better cognitive outcomes among persons with longer durations of residence in the United States (21, 22). Education has received limited exploration in acculturation-cognition research, despite extensive links to both, and a greater focus on the role of education may provide greater insight into the association between acculturation and cognition (10, 12, 13, 23–27).

We examined how a validated measure of US acculturation was associated with cognitive performance and with dementia/cognitive impairment, no dementia (CIND) over a period of 10 years among older, low–socioeconomic position (SEP) Latinos. On the basis of prior cognitive research with acculturation proxies and in contrast with negative acculturation theory, we hypothesized that 1) participants who were less acculturated toward the United States would have higher dementia/CIND risk and accelerated cognitive decline, and 2) the cognitive impact of low acculturation would be more severe for less educated persons.

METHODS

Study population

Participants were drawn from the Sacramento Area Latino Study on Aging (SALSA), a 10-year longitudinal cohort study of 1,789 older (aged ≥60 years), community-dwelling Latinos (predominantly of Mexican descent) in Sacramento, California (28). Baseline age ranged from 60 years to 101 years (1998–1999). Home visits occurred every 12–13 months until 2008, for a maximum of 7 follow-up visits. Interviewer-administered surveys in English or Spanish collected health, lifestyle, and sociodemographic data. Clinical and cognitive assessments were completed. Informed consent was obtained from all participants, and study procedures were approved by institutional review boards. Additional details have been previously published (28, 29).

Average annual attrition was 5% (28, 30). Participants lacking acculturation or cognition data ($n = 11$), those with limited follow-up (<2 visits; $n = 253$), and those with baseline dementia/CIND ($n = 95$) were excluded, which left 1,430 participants for unweighted supplemental analyses. We created inverse probability of censoring weights (IPCW) to account for attrition, and 12 participants lacked data on covariates, which left 1,418 eligible participants for weighted analyses.

Measures

Acculturation. All acculturation measures were assessed at baseline using the validated Acculturation Rating Scale for Mexican Americans–Version II (ARSMA-II), a 30-item multidimensional measure that captures information on language, ethnic identity, and ethnic interactions (31, 32). ARSMA-II has 2 acculturation scales: Anglo, herein referred to as "US," and Mexican. Points for each question are averaged within each scale, and the Mexican score is then subtracted from the US score to obtain an overall mean score. The US and Mexican subscales of ARSMA-II have strong internal reliability (Cronbach's α: $\alpha = 0.83$ and $\alpha = 0.88$, respectively) and test-retest reliability at 1-week intervals ($\rho = 0.94$ and $\rho = 0.96$, respectively), as well as strong concurrent validity with the original ARSMA ($\rho = 0.89$) (31, 32). We modified cutpoints for dichotomous total US acculturation: ≥0 indicates "high" and <0 indicates "low" (i.e., acculturated toward non-US birth/ancestral country) (31). We combined the small bicultural sample (score = 0; <1%) with persons with high US acculturation (score > 0) because our population was US-based; therefore, exposure to US culture was likely stronger (33).

Language is a driver of acculturation (10). For an acculturation sensitivity assessment, we parsed apart the ARSMA-II measures into cultural language use/preference measures and identity measures and created 2 separate exposures to determine whether language drove cognitive associations. Language use and preference, herein called "language," was measured with questions on interpersonal communications and media. Identity was measured with questions on social interaction, ethnic identity, and cultural practice and traditions. We calculated individual high/low scores for language- and identity-related acculturation as we did for total US acculturation. Participants scoring as bicultural for language and identity were few (<6% and <1%, respectively).

Bilingualism may benefit cognition via enhanced cognitive reserve (19, 34). Despite a small sample size, we conducted a bicultural language sensitivity assessment for the relationship between a 3-level (high, bicultural, and low) language-related US acculturation exposure and cognitive performance. As for total acculturation, ARSMA-II language questions were scored and high, bicultural, and low scores were designated >0, 0, and <0, respectively.

Cognitive performance. Cognitive performance was assessed using the Modified Mini-Mental State Examination (3MSE), a 100-point global test validated and field-tested in English and Spanish (35). Higher scores indicated better

performance. The 3MSE shows better reliability, test-retest properties, sensitivity, and specificity than the Mini-Mental State Examination and has fewer ceiling effects (35, 36). With repeated measures, we examined cognitive decline over a period of 10 years. Errors were calculated for each assessment and log-transformed for normal distribution (log(101 − 3MSE score)) (37, 38). More errors indicated worse cognition and, over time, decline.

Dementia/CIND. Dementia/CIND was diagnosed in 3 stages. First, the 3MSE and the Spanish English Verbal Learning Test (SEVLT), a 15-point verbal memory recall test with five 15-word trials, were administered. The SEVLT has been validated in English and Spanish, and the final trial score is usually taken (39, 40). If participants scored less than the 20th percentile on either test or if their scores declined by more than 8 3MSE points or more than 3 SEVLT points from the previous assessment, they were referred for further testing. Second, the Spanish and English Neuropsychological Assessment Scales (SENAS) (41) and the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) (42) were administered. Participants were referred for more testing if they scored as follows: ≥3.40 points on the IQCODE and <10th percentile on ≥1 SENAS tests; <10th percentile on ≥4 SENAS tests; or >4.0 points on the IQCODE. Third, neurologists and neuropsychologists used the criteria of the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*, the National Institute of Neurological and Communicative Disorders and Stroke, and the Alzheimer's Disease and Related Disorders Association to diagnose dementia/CIND. Demented participants then underwent magnetic resonance imaging and laboratory testing.

Potential confounders. We considered the following types of factors as confounders in directed acyclic graphs (43): sociodemographic (age, sex, nativity, survey language, migration age, duration of US residence, marital status, education, lifetime occupation, employment), lifestyle (diet, physical activity, smoking, alcohol, sleep), and health (self-reported health, depression, body mass index (weight (kg)/height (m)^2), insurance status). Final adjustment excluded variables identified as mediators.

Effect measure modifier. We examined education as a modifier of acculturation-cognition associations. We dichotomized education (<12 years, "low"; ≥12 years, "high") on the basis of the distribution of education in the study population and previous research among SALSA and similar populations (33, 44, 45).

Statistical analysis

Main analyses. Analyses were conducted in SAS 9.4 (SAS Institute, Inc., Cary, North Carolina).

For cognitive performance and decline, we used linear mixed models to produce β coefficients and 95% confidence intervals (46). A higher β coefficient indicated more errors (a lower cognitive score) and, for slope over time, accelerated decline. We used an unstructured correlation structure for within-subject associations and a random intercept (baseline

cognitive performance) and slope (linear rate of cognitive change). For incident dementia/CIND, we used competing-risk regression models to produce hazard ratios and 95% confidence intervals and to account for the competing risk of death (47). Participants were observed from study entry to the date of dementia/CIND diagnosis (event of interest), death (competing event), or censoring (last contact date). Time was operationalized as grand-mean-centered visit age (70 years) for both analyses.

We adjusted for 3 sets of confounders. All models included baseline age (43, 48); cognitive performance analyses adjusted for practice effects with first- and second-assessment indicators (49). Model 1 additionally accounted for sex and marital status for demographic adjustment. Model 2 additionally adjusted for education to explore the role of confounding (33, 44, 45). Model 3 additionally adjusted for survey language to account for cultural bias in cognitive testing among persons with greater exposure to US culture and English (50, 51). Modification analyses were conducted within high/low education strata.

We used IPCW for attrition across study visits that was not due to mortality (52, 53). Numerator and denominator models adjusted for visit, quadratic visit, and US acculturation, and denominator models additionally adjusted for age, sex, education, survey language, cognitive score, self-rated health, diabetes, and depression. The IPCW weight mean was 0.99 (standard deviation, 0.36), with a range of 0.27–7.78. Web Table 1 (available at https://doi.org/10.1093/aje/kwaa088) displays unweighted and weighted characteristics by attrition.

Sensitivity assessments. First, in primary analyses, we divided total acculturation into 2 separate dimensions of language-related and identity-related acculturation, treating each as a dichotomous exposure. Second, in primary analyses, we evaluated the 3-level language acculturation exposure measure to investigate whether bicultural language use may drive beneficial associations with cognitive decline. Third, in supplemental assessments, we examined 2 additional sets of adjustment covariates: 1) adjusting for acculturation proxies to isolate the ARSMA-II exposure, though these factors are highly interrelated, and 2) adjusting for health insurance status given its role in dementia diagnosis, though the direction of association from acculturation is debatable. Fourth, in supplemental assessments, we excluded bicultural total acculturation participants from all cognitive analyses to ensure that they did not drive results.

RESULTS

Table 1 displays descriptive characteristics overall and by total US acculturation and education strata for 1,418 participants. The median age of participants was 68 years; 60.1% were female, and 49.7% were US-born. The median duration of education was 6 years. Levels of total, language-related, and identity-related US acculturation were high for 37.0%, 47.9%, and 17.2% of participants, respectively. The median 3MSE score at baseline was 89, and 10.6% of participants had incident dementia/CIND. During the study, 282 participants (20%) died (data not shown); among those

Table 1.   IPCW-Weighted Sociodemographic and Health Characteristics of Participants, Overall and by Total US Acculturation and Educational Level, Sacramento Area Latino Study on Aging, Sacramento, California, 1998–2008

			Total US Acculturation				Educational Level[b]			
	Overall		Low		High		Low		High	
Characteristic[a]	No.	%	No.	%	No.	%	No.	%	No.	%
All participants	1,418	100.0	896	63.0	522	37.0	959	72.0	459	28.0
Age, years[c]	68.1 (64.1–73.1)		68.2 (64.1–73.2)		67.8 (64.0–72.6)		68.5 (64.2–73.6)		66.8 (63.7–71.5)	
Female sex (vs. male)	824	60.1	539	62.3	285	56.2	579	62.7	245	53.4
US nativity (vs. non-US birth[d])	719	49.7	252	26.1	467	90.1	364	38.1	355	79.7
Age at migration, years[c,e]	30.0 (20.0–47.1)		32.0 (21.0–48.0)		2.0 (1.0–12.0)		32.0 (20.8–48.2)		21.0 (7.6.–30.0)	
Marriage/domestic partnership (vs. none)	851	60.8	544	62.2	307	58.3	573	60.8	278	60.6
Missing data	1		1		0		1			
High educational level (vs. low)	459	28.0	141	12.0	318	55.2	0	0.0	459	100.0
Duration of education, years[c]	6.0 (3.0–12.0)		7.0 (4.0–12.0)		12.0 (9.0–14.0)		4.0 (1.0–8.0)		13.0 (12.0–15.0)	
Major lifetime occupation										
Nonmanual	321	20.9	116	11.7	205	36.7	72	7.4	249	56.2
Manual	839	60.5	600	67.6	239	48.2	689	70.9	150	33.1
Other[f]	242	18.7	171	20.7	71	15.1	192	21.7	50	10.8
Missing data	16		9		7		6		10	
Gross household income, dollars/month										
<1,000	579	24.7	475	57.1	104	21.8	496	54.4	83	17.3
1,000–1,999	455	31.3	276	29.6	179	34.4	325	32.6	130	28.0
≥2,000	365	44.0	131	13.4	234	43.9	124	13.0	241	54.7
Missing data	19		14		5		14		5	
English survey language (vs. Spanish)	641	45.0	162	17.4	479	92.2	275	30.3	366	83.0
Health insurance coverage (vs. none)	1,296	89.5	788	85.1	508	96.9	853	86.8	443	96.3
Missing data	2		1		1		2		0	
Self-rated health of good or better (vs. less than good)	765	52.8	413	45.3	352	65.7	429	44.6	336	73.9
Body mass index[g]										
<25	243	17.2	144	16.3	99	18.8	162	17.1	81	17.6
25–29	524	38.5	336	39.8	188	36.5	351	38.0	173	39.8
≥30	591	44.3	366	44.0	225	44.7	401	44.9	190	42.6
Missing data	60		50		10		45		15	
Any alcohol consumption (vs. none)[h]	815	56.1	470	50.6	345	65.4	500	51.2	315	68.7
Smoking status										
Never smoker	645	46.2	409	46.9	236	45.0	422	45.3	223	48.4
Former smoker	614	41.9	383	40.7	231	43.9	421	41.8	193	42.2
Current smoker	159	11.9	104	12.4	55	11.1	116	12.9	43	9.4

Table continues

Table 1. Continued

Characteristic[a]	Overall		Total US Acculturation				Educational Level[b]			
			Low		High		Low		High	
	No.	%	No.	%	No.	%	No.	%	No.	%
Overall fatigue in past month (vs. none)										
Baseline	391	28.3	246	28.5	145	28.0	274	29.4	117	25.4
Ever during study period	682	47.9	433	48.3	249	47.2	474	49.6	208	43.6
Restless sleep in past week (vs. none)										
Baseline	322	21.8	243	26.1	79	14.5	249	24.2	73	15.6
Ever during study period	755	53.0	534	59.1	221	42.5	567	58.5	188	38.8
High level of depressive symptoms (vs. low)[i]										
Baseline	337	23.8	259	29.0	78	15.1	280	28.4	57	11.9
Ever during study period	788	56.4	543	61.2	245	48.1	596	62.6	192	40.3
Diabetes diagnosis (vs. none)										
Baseline	438	31.8	270	30.9	168	33.3	301	32.5	137	30.1
Ever during study period	645	46.5	404	46.2	241	46.9	443	47.7	202	43.3
High US acculturation (vs. low)[j]										
Total acculturation	522	37.0	0	0.0	522	100.0	204	23.0	318	72.9
Language-related acculturation	691	47.9	177	18.4	514	98.3	304	32.6	387	87.4
Identity-related acculturation	247	17.2	8	0.7	239	45.3	88	9.9	159	35.9
3MSE score (raw score)[c]	89.0 (81.0–94.0)		85.0 (78.0–91.0)		93.0 (88.0–97.0)		86.0 (79.0–91.0)		95.0 (91.0–97.0)	
Incident dementia/CIND diagnosis (vs. none)	142	10.6	103	12.1	39	7.9	117	12.5	25	5.6

Abbreviations: CIND, cognitive impairment, no dementia; GED, General Educational Development; IPCW, inverse probability of censoring weights; 3MSE, Modified Mini-Mental State Examination.

[a] Information was collected at baseline unless otherwise stated.
[b] Educational level was dichotomized: high, ≥12 years/high school/GED; low, <12 years/high school/GED.
[c] Values are expressed as median (interquartile range).
[d] Country of non-US birth: Mexico, 88.8%; other, 11.2%.
[e] Migration age was restricted to 721 non-US-born participants.
[f] Includes participants categorized as unemployed or housewives.
[g] Weight (kg)/height (m)^2.
[h] Beer, wine, or liquor.
[i] 20-item Center for Epidemiologic Studies Depression Scale score ≥16 = high.
[j] Assessed by means of the Acculturation Rating Scale for Mexican Americans–Version II.

who were free of dementia/CIND ($n = 1,276$), death was a competing risk for 228 participants (18%).

Total US acculturation

Cognitive performance and decline. <u>Overall.</u> In fully adjusted models, participants with a high level of acculturation made 0.21 fewer cognitive errors at age 70 years (better performance at the grand-mean-centered age) than those with low acculturation (model 3: acculturation β = −0.21 (standard error (SE), 0.05)) (Table 2, Figure 1A).

Rate of decline did not differ by acculturation (model 3: acculturation × age β = 0.00 (SE, 0.00)).

<u>By education.</u> For both education strata, cognitive performance was better among high-acculturation participants than among low-acculturation participants, with similar magnitudes (model 3: for low education, acculturation β = −0.21 (SE, 0.06); for high education, β = −0.20 (SE, 0.07)), and decline did not vary.

Incident dementia/CIND. <u>Overall.</u> In models that adjusted for age, sex, and marital status, high acculturation was

Table 2. IPCW-Weighted Changes in Cognitive Assessment Scores (β (Standard Error)) According to Total US Acculturation, Overall and by Educational Level[a], Sacramento Area Latino Study on Aging, Sacramento, California, 1998–2008

Variable	Model			
	Crude	Model 1[b]	Model 2[c]	Model 3[d]
Overall (*n* = 1,418)				
High US acculturation (vs. low)	−0.61 (0.04)[e]	−0.59 (0.04)[e]	−0.33 (0.04)[e]	−0.21 (0.05)[e]
Age (per year)	0.03 (0.00)[e]	0.09 (0.00)[e]	0.09 (0.00)[e]	0.09 (0.00)[e]
High US acculturation × age	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Low educational level (*n* = 959)				
High US acculturation	−0.41 (0.05)[e]	−0.41 (0.05)[e]		−0.21 (0.06)[e]
Age	0.03 (0.00)[e]	0.08 (0.01)[e]		0.08 (0.01)[e]
High US acculturation × age	−0.00 (0.01)	−0.00 (0.01)		−0.00 (0.01)
High educational level (*n* = 459)				
High US acculturation	−0.19 (0.06)[e]	−0.16 (0.06)[e]		−0.20 (0.07)[e]
Age	0.04 (0.01)[e]	0.12 (0.01)[e]		0.12 (0.01)[e]
High US acculturation × age	−0.00 (0.01)	0.00 (0.01)		−0.00 (0.01)

Abbreviations: GED, General Educational Development; IPCW, inverse probability of censoring weights.
[a] Educational level was dichotomized: high, ≥12 years/high school/GED; low, <12 years/high school/GED.
[b] Adjusted for baseline age, practice effects, sex, and marital status.
[c] Adjusted for baseline age, practice effects, sex, marital status, and education.
[d] Adjusted for baseline age, practice effects, sex, marital status, survey language, and, in overall models, education.
[e] $P \leq 0.05$ (2-sided).

associated with reduced dementia/CIND risk (model 1: hazard ratio (HR) = 0.62, 95% confidence interval (CI): 0.44, 0.89) (Table 3). After additional adjustment for education and language, the association became null, potentially because of limited statistical power (model 2: HR = 0.75 (95% CI: 0.51, 1.10); model 3: HR = 0.81 (95% CI: 0.49, 1.35)).

By education. ducation did not modify the association between total acculturation and incident dementia/CIND, but fully adjusted effect estimates suggested that statistical

Table 3. IPCW-Weighted Risk of Incident Dementia/CIND According to Total US Acculturation (High vs. Low), Overall and by Educational Level, Sacramento Area Latino Study on Aging, Sacramento, California, 1998–2008

Model	Overall (*n* = 1,418)		Educational Level[a]			
			Low (*n* = 959)		High (*n* = 459)	
	HR	95% CI	HR	95% CI	HR	95% CI
Crude	0.64[b]	0.45, 0.91	0.75	0.49, 1.15	0.73	0.30, 1.79
Model 1[c]	0.62[b]	0.44, 0.89	0.74	0.49, 1.14	0.73	0.30, 1.80
Model 2[d]	0.75	0.51, 1.10				
Model 3[e]	0.81	0.49, 1.35	0.91	0.51, 1.63	0.48	0.18, 1.30

Abbreviations: CI, confidence interval; CIND, cognitive impairment, no dementia; GED, General Educational Development; HR, hazard ratio; IPCW, inverse probability of censoring weights.
[a] Educational level was dichotomized: high, ≥12 years/high school/GED; low, <12 years/high school/GED.
[b] $P \leq 0.05$ (2-sided).
[c] Adjusted for baseline age, sex, and marital status.
[d] Adjusted for baseline age, sex, marital status, and education.
[e] Adjusted for baseline age, sex, marital status, survey language, and, in overall models, education.
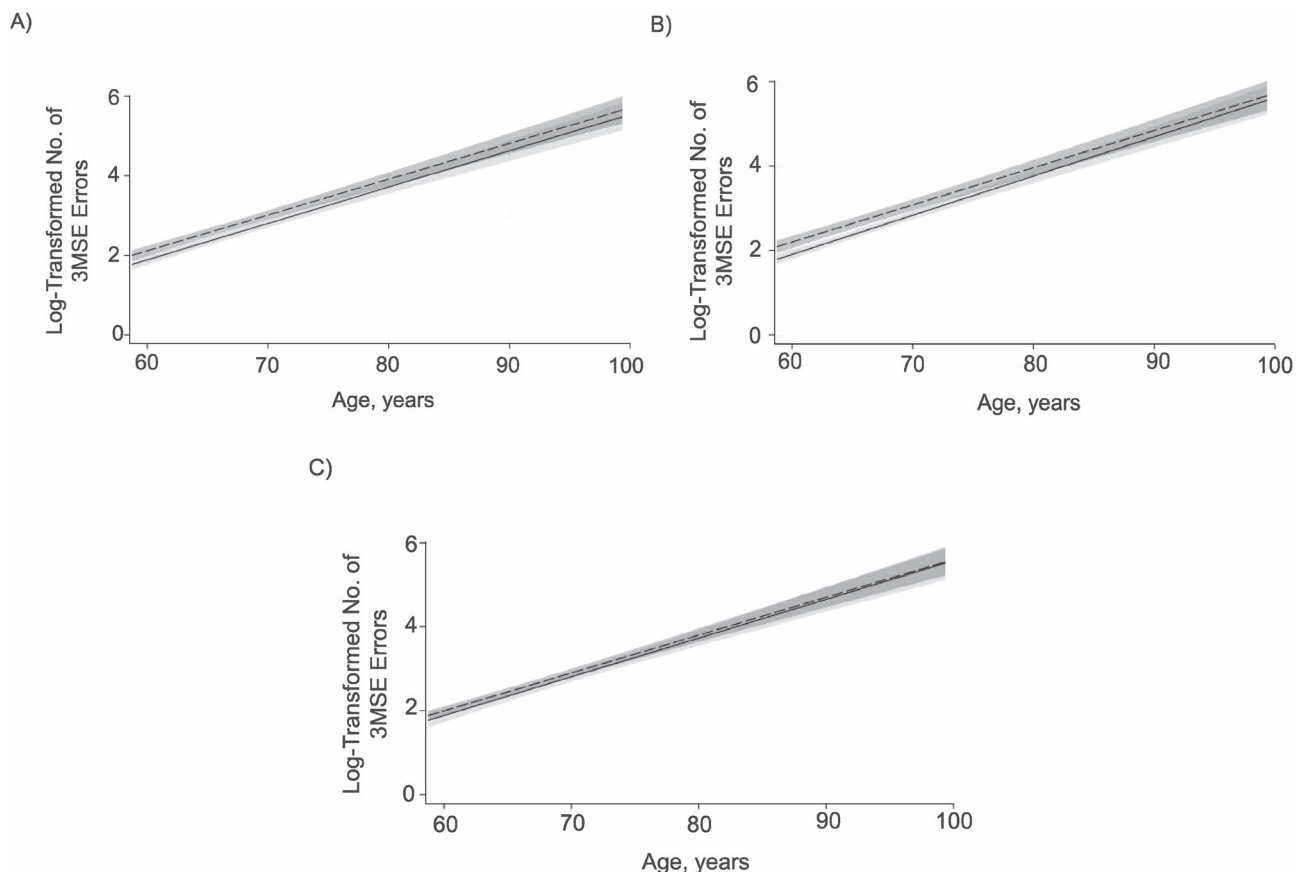
Figure 1.   IPCW-weighted and adjusted changes in cognitive assessment scores by level of total (A), language-related (B), and identity-related (C) US acculturation (n = 1,418), Sacramento Area Latino Study on Aging, Sacramento, California, 1998–2008. Dashed lines, low acculturation; solid lines, high acculturation. The lines correspond to β coefficients, and the shaded areas show 95% confidence intervals. Results were adjusted for baseline age, sex, marital status, survey language, and education. IPCW, inverse probability of censoring weights; 3MSE, Modified Mini-Mental State Examination.

power was limited (model 3: for low education, HR = 0.91 (95% CI: 0.51, 1.63); for high education, HR = 0.48 (95% CI: 0.18, 1.30)).

Sensitivity assessment for language-related and identity-related US acculturation

Cognitive performance and decline.   Language-related acculturation results were comparable to total accultur-ation results for overall models (Figure 1B) but not for educational strata (Table 4). Cognition at age 70 years was better with high language acculturation than with low language acculturation among low-education participants, but cognition did not differ by language acculturation for high-education participants (model 3: acculturation β = −0.25 (SE, 0.07) and β = −0.11 (SE, 0.11), respectively). Identity-related acculturation results differed from those for total acculturation and language acculturation for overall models (Figure 1C) and educational strata. Overall and for low-education participants, high identity acculturation was not associated with cognition at age 70 years (model 3:

acculturation β = −0.09 (SE, 0.05) and β = −0.02 (SE, 0.08), respectively). However, for persons with a high level of education, high identity acculturation was associated with better cognitive performance at age 70 years than for those with low education (model 3: acculturation β = −0.15 (SE, 0.06)).

Incident dementia/CIND.   As with total acculturation, nei-ther language-related acculturation nor identity-related ac-culturation was associated with dementia/CIND (Table 5). Education was not a modifier.

Sensitivity assessment for bicultural language-related US acculturation: cognitive performance and decline

Prevalences of high, bicultural, and low language-related acculturation were 43.3% (n = 614), 5.4% (n = 77), and 51.3% (n = 727), respectively (data not shown). Overall, participants with high language acculturation had better cognitive performance at age 70 years than participants

Table 4. IPCW-Weighted Changes in Cognitive Assessment Scores (β (Standard Error)) According to Language-Related and Identity-Related US Acculturation, Overall and by Educational Level[a], Sacramento Area Latino Study on Aging, Sacramento, California, 1998–2008

Variable	Acculturation Variable and Model							
	Language-Related Acculturation				Identity-Related Acculturation			
	Crude	Model 1[b]	Model 2[c]	Model 3[d]	Crude	Model 1[b]	Model 2[c]	Model 3[d]
Overall (n = 1,418)								
High US acculturation (vs. low)	−0.62 (0.03)[e]	−0.61 (0.03)[e]	−0.34 (0.04)[e]	−0.25 (0.06)[e]	−0.49 (0.05)[e]	−0.47 (0.05)[e]	−0.20 (0.05)[e]	−0.09 (0.05)
Age (per year)	0.03 (0.00)[e]	0.09 (0.01)[e]	0.09 (0.01)[e]	0.09 (0.01)[e]	0.03 (0.00)[e]	0.09 (0.01)[e]	0.09 (0.00)[e]	0.09 (0.00)[e]
High US acculturation × age	0.01 (0.00)[e]	0.01 (0.00)[e]	0.01 (0.00)	0.00 (0.00)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)
Low educational level (n = 959)								
High US acculturation	−0.41 (0.04)[e]	−0.40 (0.04)[e]		−0.25 (0.07)[e]	−0.28 (0.07)[e]	−0.27 (0.07)[e]		−0.02 (0.08)
Age	0.03 (0.00)[e]	0.08 (0.01)[e]		0.08 (0.01)[e]	0.03 (0.00)[e]	0.08 (0.01)[e]		0.08 (0.01)[e]
High US acculturation × age	0.00 (0.00)	0.00 (0.01)		0.00 (0.01)	0.00 (0.01)	−0.00 (0.01)		0.00 (0.01)
High educational level (n = 459)								
High US acculturation	−0.11 (0.08)	−0.10 (0.08)		−0.11 (0.11)	−0.17 (0.06)[e]	−0.15 (0.06)[e]		−0.15 (0.06)[e]
Age	0.03 (0.01)[e]	0.12 (0.01)[e]		0.12 (0.01)[e]	0.04 (0.01)[e]	0.12 (0.01)[e]		0.12 (0.01)[e]
High US acculturation × age	0.00 (0.01)	0.00 (0.01)		0.00 (0.01)	−0.00 (0.01)	−0.00 (0.01)		−0.00 (0.01)

Abbreviations: GED, General Educational Development; IPCW, inverse probability of censoring weights.
a Educational level was dichotomized: high, ≥12 years/high school/GED; low, <12 years/high school/GED.
b Adjusted for baseline age, practice effects, sex, and marital status.
c Adjusted for baseline age, practice effects, sex, marital status, and education.
d Adjusted for baseline age, practice effects, sex, marital status, survey language, and, in overall models, education.
e $P \leq 0.05$ (2-sided).

Table 5. IPCW-Weighted Risk of Incident Dementia/CIND According to Language-Related or Identity-Related US Acculturation, Overall and by Educational Level[a], Sacramento Area Latino Study on Aging, Sacramento, California, 1998–2008

Acculturation Variable and Model	Overall (*n* = 1,418)		Educational Level[a]			
			Low (*n* = 959)		High (*n* = 459)	
	HR	95% CI	HR	95% CI	HR	95% CI
High language-related US acculturation (vs. low)						
Crude	0.69[b]	0.50, 0.95	0.80	0.55, 1.15	1.03	0.29, 3.71
Model 1[c]	0.63[b]	0.45, 0.89	0.73	0.50, 1.08	1.00	0.28, 3.63
Model 2[d]	0.76	0.53, 1.08				
Model 3[e]	0.81	0.51, 1.30	0.85	0.53, 1.38	0.51	0.07, 3.89
High identity-related US acculturation (vs. low)						
Crude	0.58[b]	0.35, 0.95	0.81	0.46, 1.45	0.41	0.15, 1.12
Model 1[c]	0.62	0.37, 1.01	0.84	0.47, 1.52	0.43	0.16, 1.21
Model 2[d]	0.72	0.43, 1.22				
Model 3[e]	0.79	0.46, 1.37	1.02	0.54, 1.92	0.37	0.13, 1.07

Abbreviations: CI, confidence interval; CIND, cognitive impairment, no dementia; GED, General Educational Development; HR, hazard ratio; IPCW, inverse probability of censoring weights.

[a] Educational level was dichotomized: high, ≥12 years/high school/GED; low, <12 years/high school/GED.

[b] $P \leq 0.05$ (2-sided).

[c] Adjusted for baseline age, sex, and marital status.

[d] Adjusted for baseline age, sex, marital status, and education.

[e] Adjusted for baseline age, sex, marital status, survey language, and, in overall models, education.

with low language acculturation (model 3: acculturation β = −0.29 (SE, 0.06)) (Table 6). In comparison with low language acculturation, we did not detect an association between bicultural language acculturation and cognitive performance. Cognitive decline also did not vary.

Supplemental sensitivity assessments

Remaining sensitivity assessments for unweighted analyses (Web Tables 2–6), additional sets of adjustment covariates (Web Tables 7 and 8), and exclusion of bicultural total acculturation participants (Web Tables 9 and 10) did not meaningfully alter our results or conclusions.

DISCUSSION

To our knowledge, this was the first population-based longitudinal study to examine associations between multidimensional US acculturation, cognitive performance and decline, and incident dementia/CIND. Supporting prior cognitive research in Latinos and in contrast with the negative acculturation hypothesis, high-US-acculturation participants had better cognitive performance than those with low acculturation (i.e., cultural orientation toward another birth/ancestral country). Cognitive decline and

dementia/CIND risk did not vary by acculturation, regardless of education. High language-related acculturation may have stronger beneficial associations with cognitive performance than identity-related acculturation (e.g., self-identity, traditions, social interactions), signifying that language use is salient for cognitive testing scores. Overall, among these older, low-SEP US Latinos, high acculturation was associated with better cognitive performance but not with cognitive decline or dementia/CIND risk.

Cognitive decline did not vary by acculturation, but acculturative differences in cognitive performance were present at study onset (median age, 68 years). Generally, high US acculturation has been linked to poor cardiovascular health and determinants (1, 6, 54, 55), which are key in the etiology of cognitive decline and dementia (38, 54, 56). However, the association between US acculturation and cardiovascular health may be reversed for older Latinos (57, 58). In previous SALSA research, López et al. (57) identified a beneficial association between high US acculturation and some cardiovascular factors (e.g., blood pressure, cholesterol, physical activity), which may partially explain our findings. Moreover, predictors of poor cognition like depression, stress, and poor sleep are more common with low acculturation among older Latinos and SALSA participants (29, 59–67), highlighting other potential mediating pathways. For example, given their lower education, income, and English use,

Table 6.   IPCW-Weighted Changes in Cognitive Assessment Scores (β (Standard Error)) According to a 3-Level Measure of Language-Related US Acculturation ($n = 1,418$), Sacramento Area Latino Study on Aging, Sacramento, California, 1998–2008

Variable	Model			
	Crude	Model 1[a]	Model 2[b]	Model 3[c]
US acculturation				
Bicultural (vs. low)	−0.40 (0.08)[d]	−0.40 (0.08)[d]	−0.18 (0.07)[d]	−0.14 (0.08)
High (vs. low)	−0.65 (0.04)[d]	−0.63 (0.04)[d]	−0.37 (0.04)[d]	−0.29 (0.06)[d]
Age (per year)	0.03 (0.00)[d]	0.09 (0.01)[d]	0.09 (0.01)[d]	0.09 (0.01)[d]
US acculturation × age				
Bicultural (vs. low)	0.02 (0.01)[d]	0.02 (0.01)[d]	0.02 (0.01)[d]	0.02 (0.01)
High (vs. low)	0.01 (0.00)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)

Abbreviations: IPCW, inverse probability of censoring weights.
[a] Adjusted for baseline age, practice effects, sex, and marital status.
[b] Adjusted for baseline age, practice effects, sex, marital status, and education.
[c] Adjusted for baseline age, practice effects, sex, marital status, education, and survey language.
[d] $P \leq 0.05$ (2-sided).

socioeconomic and acculturative stressors were probably more prevalent among SALSA participants with low US acculturation (68, 69).

Acculturation and late-life cognition are shaped across the life course: For example, cognitive decline begins at 20–30 years of age (9, 70, 71). Further, risk factors linked to acculturation (e.g., SEP, chronic conditions) are determinants of life-course cognitive trajectories even in early and midlife (72). Similarly, differences in decline by acculturation for SALSA may have occurred before study onset, which would explain why we only observed established differences in cognitive performance. While acculturation was not associated with cognitive decline in this work, our findings indicate that downstream pathways of low acculturation should be examined as potential drivers of decline in future research.

Education, commonly established in early to midlife, informs social determinants and trajectories of acculturation and cognition (10, 12, 13, 23–27). Education and acculturation in SALSA were closely linked: 55% of high-acculturation participants had a high level of education, as compared with 12% of low-acculturation participants; and 23% of low-education participants (median duration of education, 4 years) had high acculturation, as compared with 73% of high-education participants (median duration of education, 13 years). Cognitive scores at study onset were also better among high-education participants. We expected these differences, since greater acculturation (e.g., English fluency) facilitates social advantages like excelling within educational systems (10, 13, 73). High education is also associated with enhanced cognitive reserve and other positive health outcomes (e.g., access to health care) (23–27). Yet a cognitive advantage among high-acculturation participants persisted across educational strata, even when adjusting for nativity and migration age in supplemental analyses, which should partially account for educational content differences.

High US acculturation was not predictive of dementia/CIND risk when adjusting for demographic factors, education, and survey language, regardless of acculturation type (language-related or identity-related). However, small sample sizes may have limited our power to detect associations, as estimates suggested reduced dementia/CIND risk for high US acculturation. Still, differing results between cognitive performance and dementia/CIND may highlight the importance of cognitive reserve in the expression of clinical dementia. Education shapes cognitive outcomes via multiple pathways (23–27), but high cognitive reserve is posited to offset expression of dementia's physical brain degeneration (23). Whether acculturation shapes dementia/CIND risk independently of education should be explored further in larger populations.

Language-related acculturation, rather than identity-related acculturation (e.g., traditions, interactions), may drive acculturative differences in cognitive performance and scoring. In the same vein, bilingualism has been hypothesized to enhance cognitive reserve, but the literature is inconsistent, including null findings for cognitive trajectories in SALSA (19, 34). We explored this further in a bicultural language supplemental sensitivity assessment, despite the small sample size. Cognitive performance was better for participants with high language acculturation than for those with low language acculturation, providing confidence that beneficial associations were not attributable to bicultural language use. However, estimates for bicultural language acculturation also suggested a beneficial association. To further interrogate cognitive differences by acculturation subtypes and bicultural language use, larger, more diverse populations and validated approaches for acculturation subtypes are needed, given our modified approach (31).

SEP was low overall in our study population (e.g., a median of 6 years of education and a household income less than $2,000/month for 56% of participants). When SEP

is low, high US acculturation may be beneficial for health outcomes (57, 74, 75). Factors like improved health-care access, which is especially important for older populations as chronic disease becomes more common, and stronger social networks may serve as underlying pathways (6, 12, 57, 76–78). However, the mediating dynamics of downstream acculturation pathways require further exploration.

Our study had limitations. First, we used a modified ARSMA-II approach and were unable to fully assess biculturalism given the sample size. However, in a supplemental sensitivity assessment, we excluded persons with bicultural acculturation, which gave confidence to our findings. Second, attrition was a concern, but IPCW accounted for this dropout (52, 53). Third, survivor bias and depletion of exposed (i.e., susceptible) individuals were concerns in our older study population (79, 80). Depletion can lead to a reversal of association (81), but findings were supported by previous literature (16, 17). Fourth, our binary high/low treatment of education may have led to residual confounding, but we based the cutpoint on sample size, population distributions, and previous research (33, 44, 45).

Fifth, we were limited in terms of power to detect associations for dementia/CIND. Sixth, as noted, there are known biases in cognitive testing with higher acculturation and education, but we attempted to account for these biases with covariate adjustment. Moreover, the 3MSE is a brief, global cognitive screening instrument, and we could not draw conclusions about specific cognitive domains. Finally, our study population comprised predominantly low-SEP, Mexican-descent participants, and the ARSMA-II was created for Mexican Americans; therefore, results may not be generalizable to Latinos overall or to other subgroups. However, it is reasonable to hypothesize that populations and individuals with comparable acculturative experiences and immigration patterns could have similar cognitive outcomes.

Our study also had strengths. First, earlier studies mainly used proxy measures of acculturation (e.g., language use, nativity). We employed a validated scale to characterize the complex multifaceted acculturation process (31). Second, we completed multiple sensitivity assessments to further parse apart the complex acculturation process: 1) use of cultural language and identity as separate exposures, 2) assessment of bicultural language acculturation, and 3) exclusion of bicultural total acculturation participants. Third, we accounted for socioeconomic context by examining modification by education to assess the joint sociocultural pathways that shape cognition. Fourth, we used IPCW to account for selection bias. Fifth, we accounted for the competing risk of death in dementia/CIND analyses (47). Sixth, we developed a rigorous methodological approach with multiple sociocultural and clinical measures, including repeated measures of global cognition and thorough multistage diagnosis of incident dementia/CIND.

In conclusion, in this study, participants with high US acculturation had better cognitive performance than those with low US acculturation, which may be explained by cultural language use rather than factors related to identity (e.g., traditions, interactions). The findings do not support a negative acculturation hypothesis for cognitive outcomes but do support previous research that identified worse cognitive outcomes among foreign-born Mexican Americans, an acculturation proxy. Cognitive decline and dementia/CIND risk did not vary by acculturation, regardless of education, though null dementia/CIND findings may be attributable to limited power. Future studies should incorporate extended longitudinal assessments among more diverse Latino groups. If results are replicated, modifiable pathways between high US acculturation and improved health and cognition (e.g., alcohol use, diabetes) should be examined with formal mediation analyses. Identification of novel intervention points (e.g., language proficiency, health-care access) would serve to guide and advance the reduction of poor cognitive outcomes among older Latinos.

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