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Life-span Socioeconomic Trajectory, Nativity, and Cognitive Aging in Mexican Americans: The Sacramento Area Latino Study on Aging

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Objectives. Early life circumstances influence health across the life span. Migration and ethnicity may modify the lifetime trajectory of socioeconomic status (SES) and lead to heterogeneity in cognitive aging in later life.

Methods. We examined the effects of both lifetime socioeconomic trajectory and cumulative disadvantage from childhood through adulthood on late life cognitive performance in a 9-year cohort of 1,789 Mexican Americans aged 60–100 years in 1998–1999.

Results. Compared with those with low SES sustained over the life course, we found that those with more advantaged lifetime SES trajectories experienced fewer declines on a test of global cognitive function and a short-term verbal memory test. These associations are larger in first- and second-generation immigrant families.

Discussion. Heterogeneity of cognitive aging among diverse race/ethnic groups may be influenced by intergenerational changes in SES, cultural norms, and behaviors and changes in health related to changes in the social and physical environment.

Key Words: Acculturation—Cognition—Epidemiology—Life course and developmental change.

Introduction and Objective

Socioeconomic status (SES) is an important predictor of cognitive function in old age. Early life circumstances, including socioeconomic and related physical factors, are thought to influence health across the life span (Dowd, Zajacova, & Aiello, 2009; Karlamangla et al., 2009; von Ehrenstein, Mikolajczyk, & Zhang, 2009). Education generally occurs in childhood and adolescence when neurodevelopment is more rapid than in later life. More education is frequently linked to better cognitive performance and is thought to influence brain capacity and/or cognitive reserve. Education as a feature of the early socioeconomic environment has later consequences for income and occupational opportunity in adulthood, which is consistently linked to midlife and late life health status. Thus, SES in early life and midlife may indirectly influence cognitive aging via its influence on health. However, income and occupation change in old age and measures of these taken in old age do not accurately reflect the effects of SES across the life span. It is not clear whether it is the shape of the trajectory of SES change over a lifetime or whether it is accumulated disadvantage that matters most to produce greater ill health in old age in those with sustained exposure to poverty.

The bulk of work on lifetime SES trajectories or accumulated disadvantage and cognitive aging has not included assessment of the effects of race, ethnicity, or migration and cultural change on the life-span trajectory and cognitive performance. However, there is growing evidence that the impact of life course trajectories on cognitive aging may vary by ethnicity (Clarke, O'Malley, Johnston, & Schulenberg, 2009; Haas & Rohlfsen, 2009). Migration may affect the trajectory of both SES and health status, leading to differences in cognitive aging by migration history in later life. Moreover, the effects of migration on late life health may not be restricted to a single generation. Intergenerational improvements in economic and educational opportunities achieved by migration may lead to better health and cognitive aging in newer generations. Sustained intergenerational exposures to low or high SES or to upward or downward mobility are often driven by environmental changes, such as migration. The trajectory of early life to adult SES may or may not be modified by changes in cultural and socioeconomic contexts that accompany migration. Although upward mobility is often an intended goal of migration, downward mobility or sustained deprivation are also common consequences.

The purpose of this work is to examine the association between socioeconomic trajectories from childhood through adulthood with late life cognitive performance over 9 years on cognitive tests of global ability and verbal memory done in a cohort of immigrant and U.S.-born Mexican Americans. We will also evaluate the potential modifying role of migration on the association between lifetime SES and late life cognitive performance.

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Methods

Study population

Participants included in this analysis were from the Sacramento Area Latino Study on Aging (SALSA). SALSA is a longitudinal cohort study of 1,789 community-dwelling Mexican Americans residing in California's Sacramento Valley who were aged 60–101 years at baseline in 1998–1999. The majority of the participants were born in Mexico (51%) or the United States (49%). The study population and the recruitment of SALSA participants have been described in detail elsewhere (Haan et al., 2003). Participants were followed every 12–15 months via home visits that included clinical and cognitive assessments. A semiannual phone call was made to obtain updates on medications, health events, and some sociodemographic risk factors. Annual attrition from baseline through 2008 averaged 5%, including mortality and loss to follow up. SALSA was approved by the Institutional Review Board at the University of Michigan and the University of California at San Francisco and Davis.

Measures

Cognitive performance tests.—At each home visit, which was every 12–15 months, the participant received two cognitive tests: the Modified Mini-Mental State Examination (3MSE) and the Spanish English Verbal Learning Test (SEVLT). The 3MSE is a 100-point cognitive exam composed of several cognitive domains that provides an assessment of global cognitive function. It has greater sensitivity and specificity and fewer floor and ceiling effects for detecting impairment than the Mini-Mental State Examination and has excellent test–retest properties (Teng & Chui, 1987; Tombaugh, 2005). The 3MSE has been validated and field tested in Spanish and English. The SEVLT is a delayed word list recall test with four 15-word memory trials, an interference list, followed by a fifth trial, which is usually used as the test score (Gonzalez, Mungas, & Haan, 2002, 2005; Gonzalez, Mungas, Reed, Marshall, & Haan, 2001). The SEVLT was developed (Gonzalez et al., 2005) for use in SALSA and has been validated in both Spanish and English and used in other studies. Participants were allowed to be interviewed in the language of their choice.

Dementia/cognitive impairment without dementia—The procedures to diagnose dementia and cognitive impairment without dementia (CIND) have been described in detail elsewhere (Haan et al., 2003). Briefly, there were several phases of cognitive screening, a clinical exam and magnetic resonance imaging for suspected dementia cases. Standard diagnostic criteria for dementia from *Diagnostic and Statistical Manual of Mental Disorders,* 4th ed., were applied. This procedure was highly sensitive (100%) and specific (75.1%). Those with dementia/CIND at baseline are excluded from these analyses.

Socioeconomic mobility from childhood to adulthood

Childhood SES.—In baseline interviews, study participants reported the years of education completed by their mothers and fathers. Most parents did not have any formal schooling (50% of mothers and 49% of fathers), and mother's and father's education was classified as low (did not complete elementary school) or high (completed elementary school or more). Mother's occupation was classified as low (manual or housewives) or high (nonmanual), and father's occupation was classified as low (manual or unemployed) or high (nonmanual). Childhood food deprivation was measured by participants' reports as to how often they did not have enough to eat while growing up. Because 23% reported that they at least sometimes experienced food deprivation, this variable was recoded as "ever" or "never." Participants also reported the number of siblings that survived to adulthood as an indicator of early SES environment, which was then classified as "yes" (a sibling died in childhood) or "no" (none died). (All participants had at least one sibling.) Each variable included in the childhood SES score was dichotomized. To measure childhood SES, we created a composite measure that combined mother's and father's education and occupation, food deprivation, and early sibling mortality. Ranging from 0 to 6, childhood SES score was then collapsed into two categories as high (29.2%) and low (70.8%).

Adult SES.—Participant's education was obtained at the baseline interview by asking how many years of education they had completed. This was categorized into low (less than high school) or high (high school or more). Participant's occupation was classified as low (manual, unemployed, or housewives) or high (nonmanual). Participants also reported their current monthly household income, which was split at the median with low (income < $1,500) or high (income greater ≥$1,500). An additive scale was created that combined participant's education, occupation, and income that ranged from 0 to 3, where 3 denoted worse SES. Adulthood SES was then collapsed into two categories as high adulthood SES (26.4%) and low adulthood SES (73.6%).

The two-level childhood SES was then cross-classified with the two-level adulthood SES creating a four-level SES mobility variable, with each level representing a distinct SES trajectory from childhood to adulthood: all low (54.7%), high to low (18.7%), low to high (16.1%), and all high (10.5%). In analyses, all low was used as the reference category.

Cumulative SES disadvantage

A scale to measure the cumulative SES disadvantage (CD) across the life course was constructed by summing the dichotomous variables for childhood SES, education, lifetime occupation, and participants' late life household income into a scale ranging from 0 to 9.

Nativity, number of generations born in Mexico, and birth cohort

Nativity was based on the participant's self-report of their country of birth. Participants were either born in the United States or born in the Mexico and migrated to the United States. They also reported nativity for their parents and grandparents. We comprised "generations" since migration as the number reported by the participants out of three generations (e.g., grandparents, parents, and self) that had been born in Mexico (e.g., all in United States = Gen 0 [5.7%], grandparent only = Gen 1 [4.2%], parent and grandparent = Gen 2 [39.2%] or self, and parents and grandparents = Gen 3 [51%]). Participants were born between 1898 and 1939, and birth cohort was coded by birth year as: below 1920, 1920 and above to below1930, and 1930 and above.

Sociodemographic and health covariates

Health variables known from our previous work to be associated with cognitive function and dementia were selected for this analysis. Fasting glucose level was measured from blood drawn at each visit. Diabetes was defined by self-report of a physician diagnosis, use of diabetes medication, and/or a fasting glucose level greater or equal to 126 µg/dl (ADA, 2006). Prescription medication was obtained by a medicine cabinet inventory at the annual home visit and coded into groups. Blood pressure was measured using standard blood pressure protocols (Beevers, Lip, & O'Brien, 2001). Baseline hypertension was defined based on self-report of a MD diagnosis or a baseline systolic blood pressure greater than 140 mm Hg or a baseline diastolic blood pressure greater than 90 mm Hg (Association, 2010). Baseline stroke was defined by self-report of an MD diagnosis, including hospitalization for stroke. Participants also reported whether they had health insurance as well as their smoking status (ever vs. never) and alcohol consumption. These did not vary by SES or nativity and were not included in further analyses.

Statistical analyses

Analyses in this study included 1,626 participants who did not have a dementia/CIND diagnosis at baseline. Descriptive statistics of the study population were compared across the two nativity groups and two-tailed chi-square tests for categorical variables, and one-way analysis of variance for continuous variables were used to test for differences. Mixed linear models with repeated measures options were used to model the associations between SES and the two cognitive outcomes. The 3MSE was coded as the natural log of errors (log [101-score]) in order to approximate normality for the mixed linear models. Analysis of longitudinal change in the 3MSE log of errors revealed an inverse "u" nonlinear trajectory over time that was characterized by an improvement in test scores through follow-up Visit 2 and a subsequent decline in test scores through the last visit. After model-fitting tests, segmented regression was used for this analyses that involved the use of two separate time periods broken at or before or after the second follow-up visit. This is sometimes attributed to practice effects; however, Tombaugh (2005) has reported minimal such effects over periods of retesting more than a year.

The SEVLT met the normality assumptions of the mixed linear model and was not transformed. Segmentation was not used for the SEVLT because the association between time and SEVLT score was linear. In SEVLT models, time was treated as the visit number. After evaluation of unadjusted models including only the three SES terms (not shown), Model 1 included interactions between time and each indicator variable (high to high, high to low, and low to high) compared with those who remained low. Model 2 added adjustment for sociodemographic and health-related covariates. A similar strategy was pursued for the cumulative deprivation scale.

Data analysis.—Several methods have emerged in an attempt to deal with any biasing effects of attrition from longitudinal studies. These include restriction of the analysis to participants with complete data on all variables of interest, often called list-wise deletion analysis. However, the value of such restriction is founded on the unlikely assumption that data are missing completely at random (Rubin, 1976), which is rarely met in population-based studies. Therefore, we selected a more efficient and less restrictive approach for the analyses in the present study. We used a multiple imputation approach that conditioned on all data set variables as predictors in a sequence of multiple regressions (Raghunathan et al., 2001; Rubin, 1987). The different imputations are run in a cyclic manner that overwrites previously drawn values and in the interdependence between the imputed values. By using all available variables, the multiple imputation approach provides unbiased estimates while improving statistical efficiency. Five imputed data sets were produced that include all study variables and used for this analysis. All multiple linear regression models (PROC MIXED) were run in sets of five and summarized with PROC MIANALYZE (SAS v. 9.2).

Results

Table 1 displays covariates by the number of generations born in Mexico (0–3) for the study population. The percent of women was highest among Gen 0 and Gen 3 families. Gen 0 and Gen 3 families were slightly older than Gen 1 or Gen 2. Year of birth did not vary significantly by generation. Participant education was highest in Gen 0 and Gen 1 families and lowest in Gen 3 families. Participants from Gen 3 and Gen 0 families had the highest percent of manual occupations compared with Gen 2 families. Nearly everyone had health insurance, but in Gen 3 families, 16.3% did not. The percent of participants whose fathers' and mothers' education was less than elementary school was highest

Table 1. Sample characteristics of the study population at baseline by generations born in Mexico, Sacramento Area Latino Study on Aging, 1998–2008

Generation in Mexico (number)[a]	All USA born	Grandparents	Grandparent	All Mexican
Numbers	93	67	645	827
Gender: women	59.4	51.1	56.9	60.3
Age at enrollment in years (*M*/*SD*)	70.1 (7.7)	68.2 (6.1)	70.3 (6.2)	71.2 (7.7)
Birth year (*M*/*SD*)	1,928 (7.7)	1,929 (6.3)	1,928 (6.2)	1,927 (7.7)
Participant SES covariates				
Education in years (*M*/*SD*)	10.4 (5.3)	11.1 (5.0)	9.3 (4.8)	5.0 (4.7)
Household income (<$1,500/month)	51.1	41.9	48.1	79.5
Major lifetime occupation: manual	71.4	62.5	67.8	88.2
Health insurance, yes	100	95.3	97.0	83.7
Childhood SES environmental variables				
Fathers education (<elementary school)	56.7	64.98	71.8	68.9
Mothers education (<elementary school)	66.3	59.6	71.8	76.3
Fathers occupation (manual)	88.6	97.5	90.8	85.4
Participants' report of food deprivation in	22.5	24.3	18.6	10.6
Participants' report of sibling mortality in	41.0	44.2	45.9	53.6
SES mobility trajectory				
Childhood SES (% low)	54.6	67.2	72.0	71.9
Adult SES (% low)	55.8	46.7	58.7	89.5
Cumulative SES disadvantage (0–9 items)	5.3 (1.8)	5.3 (1.7)	5.7 (1.7)	6.5 (1.5)
Cognitive performance				
Baseline cognitive scores: 3MSE errors	8.1 (2.7)	6.7 (2.3)	7.5 (2.5)	11.3 (2.4)
Number of assessments for 3MSE (median)	5.0	5.0	5.0	5.0
Baseline cognitive scores: SEVLT (No. of words)	8.5 (3.1)	9.1 (2.8)	8.8 (2.9)	8.2 (2.9)
Number of assessments for SEVLT (median)	4.0	4.0	5.0	4.0
Health-related factors				
Diabetes at baseline (% present)	42.1	32.8	35.8	63.9
Treated with diabetic medication (%)	70.6	66.3	64.4	60.0
Stroke at baseline (% present)	11.7	8.1	9.8	5.7
Hypertension at baseline (% present)	54.3	54.8	65.1	60.3
Systolic blood pressure (*M*, *SD* in mm Hg)	134.6 (19.7)	136.6 (18.0)	138.7 (19.27)	138.8 (18.6)
Diastolic blood pressure (*M*, *SD* in mm Hg)	75.4 (9.6)	76.3 (9.3)	75.9 (10.9)	75.6 (10.7)

Notes: SES = socioeconomic status; SEVLT = Spanish English Verbal Learning Test; 3MSE = modified Mini-Mental State Exam.

[a]All comparisons are significant at $p < .0001$ except birth year and diastolic blood pressure ($p = .33$).

among Gen 2 and Gen 3 families. The percent of fathers with a manual occupation was highest in Gen 1 families. Hunger in childhood was lowest in Gen 3 families and highest in Gen 1 families. Sibling childhood mortality was highest in participants from Gen 3 families. Low SES in childhood or adulthood was highest in Gen 2 and Gen 3 families. Cumulative SES disadvantage was highest in Gen 3 families followed by Gen 2 families with the least CD-SES in Gen 0 families.

Baseline 3MSE errors were highest in Gen 3 families, followed by Gen 2, Gen 0, and Gen 1 families. A similar pattern was seen in the number of words recalled for the baseline SEVLT. There were no differences by generation in the median number of visits at which the 3MSE or the SEVLT was assessed. Diabetes was most prevalent among Gen 3, followed by Gen 0, Gen 2, and Gen 1, respectively. Gen 3 diabetics were less likely to be treated than Gen 0 diabetics. Stroke and hypertension were highest in Gen 0 and lowest in Gen 3. Systolic blood pressure was highest in Gen 3 and lowest in Gen 0. Diastolic blood pressure did not differ by generation.

Figure 1 illustrates the distribution of lifetime SES trajectories by the number of generations born in Mexico. Among all U.S. (Gen 0) families, there was considerable upward and downward mobility in the lives of study participants, split roughly equally between low to high and high to low. About 34% maintained high SES across the life span. Among grandparent-only families (Gen 1), 35% were always low, 32% went from low to high, 21% were always high, and nearly 12% went from high to low. Among two-generation families (Gen 2), nearly 45% remained low, 27% went from low to high, 14.5% remained high, and 13.5% went from high to low. Among three-generation families (Gen 3), more than 66% remained low, 5% remained high SES, 5.6% improved in SES, and nearly 23% of participants declined from high to low SES. Across generations, the percent of participants who remained in a low SES position declined as more generations were born in the United States. Downward mobility was highest in Gen 0 and Gen 3, whereas upward mobility was similar in Gen 0, Gen 1, and slightly lower in Gen 2. Upward mobility was lower in Gen 3. The median number of cumulative deprivations remained at 7 for the always low group and 3 for the always high group; upwardly mobile had a median of five deprivations except inGen 1 and downwardly mobile had by generation: 5.5 (Gen 0), 5 (Gen 1), and 6 (Gen 2 and Gen 3).

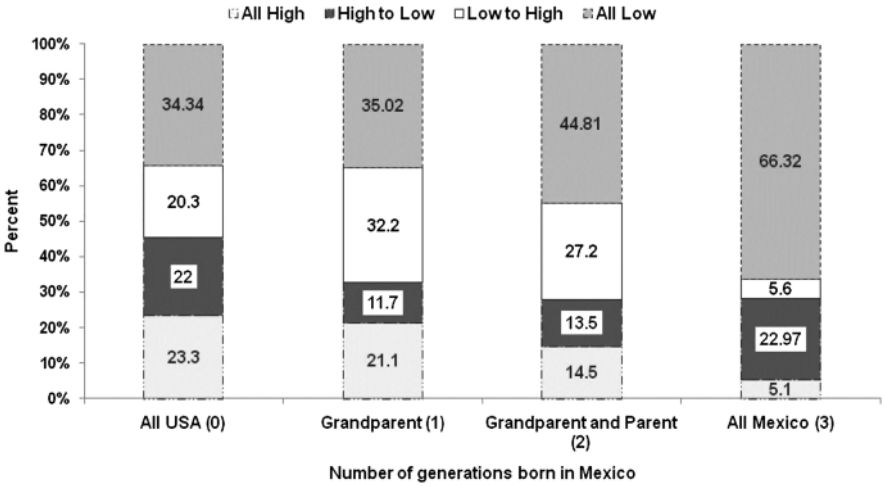

Figure 1. Distribution (percent) of childhood to adult lifetime SES trajectories by generations born in Mexico.

Table 2 presents the results of two sequential mixed linear models with the log of errors for the 3MSE as the dependent variable. Model 1 shows that those who maintained high SES throughout life and those who moved from low to high SES experienced fewer errors on the 3MSE compared with those who remained at low SES in childhood and adulthood. Those who moved from high to low SES also had fewer 3MSE errors than the low–low group, but the effect was slight compared with the high–high and low–high groups. Interactions between the three SES trajectory categories and the two time period variables were not statistically significant (not included in Table 2). Adjustment for covariates (Model 2) reduced the coefficients for high–high and low–high groups by about 18% and only slightly affected the high to low group compared with the low to low group. The 3MSE log errors among those remaining at high SES and for those moving from low to high SES are the same, whereas there is much less benefit among those moving from high to low. Older age and a larger number of generations born in Mexico were associated with more 3MSE log errors as was health insurance, diabetes, and stroke but not hypertension. Log errors on the 3MSE declined in the first time period and increased in the second. The association of the first time period to 3MSE log errors is negative and unaffected by

Table 2. Association between childhood to adulthood SES mobility trajectory and errors (log) on the 3MSE from two sequential mixed linear models

	Model 1				Model 2			
Covariates	β	Lower Confidence Limit	Upper Confidence Limit	*p* value	β	Lower Confidence Limit	Upper Confidence Limit	*p* value
Intercept	2.54	2.49	2.589	<.0001	0.078	−0.241	0.398	.629
SES mobility—childhood to adulthood								
High SES–high	−0.82	−0.93	−0.71	<.0001	−0.692	−0.797	−0.587	<.0001
High SES–low	−0.15	−0.25	−0.041	.008	−0.131	−0.229	−0.033	.011
Low SES–high	−0.82	−0.91	−0.73	<.0001	−0.683	−0.776	−0.590	<.0001
Low SES–low								
Time periods								
Period 1 (to visit)	−.18	−0.24	−0.11	<.0001	−0.170	−0.233	−0.106	<.0001
Period 2 (after)	.06	0.027	0.10	.001	0.027	−0.009	0.063	.140
Demographic								
Age at visit					0.028	0.024	0.031	<.0001
Gender					−0.028	−0.078	0.023	.278
Generations					0.075	0.044	0.106	<.0001
Health					0.213	0.131	0.294	<.0001
Health related								
Diabetes					0.139	0.087	0.190	<.0001
Stroke (yes/no)					0.172	0.070	0.274	.001
Hypertension					0.01	−0.05	0.07	.8042

Note: SES = socioeconomic status; 3MSE = modified Mini-Mental State Exam.

Table 3. Association between cumulative deprivation (CD; 0–9) and change over time in log of errors on the 3MSE from two sequential mixed linear models by generations in Mexico

	Model 1				Model 2			
Covariates	β	Lower Confidence Limit	Upper Confidence Limit	*p* value	β	Lower Confidence Limit	Upper Confidence Limit	*p* value
Intercept	1.56	1.40	1.72	.000	−0.765	−1.107	−0.422	.000
Cumulative deprivation	0.15	0.12	0.17	.0000	0.136	0.110	0.162	.000
Generations born in Mexico								
All USA 0 (all)	−0.35	−0.79	0.09	.117	−0.25	−0.68	0.19	.254
Mexican 1: (GP)	−0.74	−1.18	−0.29	.001	−0.62	−1.04	−0.20	.004
Mexican 2: (GP + P)	−0.45	−0.66	−0.24	.000	−0.30	−0.53	−0.06	.014
Mexican 3: (ref)								
Time periods								
Period 1 (to Visit 2)	−0.17	−0.21	−0.13	.000	−0.16	−0.20	−0.13	.000
Period 2 (after Visit 2)	0.06	0.04	0.09	.0000	0.02	−0.003	0.05	.08
Generations × Deprivation								
All USA 0 (all) × CD	0.04	−0.04	0.11	.34	0.016	−0.06	0.09	.662
Mexican 1: (GP) × CD	0.07	−0.01	0.15	.07	0.07	−0.005	0.14	.068
Mexican 2: (GP + P) × CD	0.03	−0.01	0.06	.111	0.004	−0.04	0.04	.819
Demographic factors								
Age at visit					0.03	0.03	0.033	.000
Gender (males/females)					−0.03	−0.08	0.023	.275
Health insurance					0.19	0.11	0.28	.000
Health-related factors								
Diabetes (yes/ no)					0.16	0.11	0.21	.000
Stroke (yes/ no)					0.16	0.07	0.26	.001
Hypertension (yes/ no)					−0.005	−0.07	0.06	.869

Note: GP = grandparents; P = parents; 3MSE = modified Mini-Mental State Exam. Model 1 includes CD, generations, and Time Period × CD (not shown).

adjustment for covariates, whereas the coefficient for the second time period is positive (more errors) and is reduced by 50% when covariates are added to the model.

In a separate analysis using mixed linear models, the bivariate association between childhood SES and 3MSE log of errors was statistically significant ($\beta = .20$, $p = .001$), but addition of adult SES ($\beta = .74$, $p \leq .0001$) to the model reduced the association between childhood SES and 3MSE by 50% ($\beta = .01$, $p = .04$). Because the coefficient for childhood SES remained significant but slight, it appears that adult SES partially mediates the association between early SES and cognitive function in old age.

Table 3 presents the results for two sequential mixed linear models with the cumulative disadvantage scale (CD) as a predictor for the 3MSE log of errors. Greater cumulative lifetime disadvantage was modestly associated with more 3MSE log errors, equivalent to a 2.1-point increase in errors for a 5-point difference in CD (the average). Adjustment for covariates only slightly affected the association between CD and the log of errors on the 3MSE. Compared with Gen 3 (all Mexican generations), Gen 0 was not associated with change in the logerrors on the 3MSE and Gen1 and Gen 2 had fewer log errors on the 3MSE. The greatest benefit for 3MSE scores is among Gen 1, followed by Gen 2, and then Gen 0 compared with Gen 3, suggesting a nonlinear pattern of effects by generation. Neither the association between CD nor the generations and 3MSE errors were modified by time/study period (not shown). The association between CD and 3MSE was not modified by the number of generations born in Mexico. Lack of health insurance, diabetes, and stroke were all associated with more errors on the 3MSE, and hypertension was not associated with the 3MSE. Tests for interaction between birth cohort and number of Mexican-born generations in relation to the log of errors on the 3MSE were not significant (not shown).

Table 4 presents the results for two sequential mixed linear models that evaluate the association between SES trajectory categories and the SEVLT score as the dependent variable. Compared with those in the always-low group, the always-high and the low–high group had higher SEVLT scores. The high–low group and the low–high group had significantly better scores than the always-low group. Time modified the associations between SES trajectory and the SEVLT such that all scores declined over time, most rapidly in the high–high and the low–high groups. This interaction was only significant for the high–high and the low–high groups compared with the always-low group. Adjustment for covariates had little influence on the association between SES trajectory and SEVLT score. Older age, lack of health insurance, diabetes, and stroke were all associated with lower SEVLT scores. Number of generations was not associated with the SEVLT score. Tests for interaction between birth cohort and number of Mexican-born generations in relation to the SEVLT were not significant (not shown).

In a separate analysis, the bivariate association between childhood SES and SEVLT score was statistically significant

Table 4. Association between childhood to adulthood SES trajectory and the SEVLT score (words recalled) from two sequential mixed linear models

	Model 1				Model 2			
	β	Lower Confidence Limit	Upper Confidence Limit	*p* value	β	Lower Confidence Limit	Upper Confidence Limit	*p* value
Intercept	8.13	7.95	8.30	<.0001	15.29	14.12	16.47	<.0001
Childhood to adulthood mobility								
High SES–high SES	1.76	1.38	2.15	<.0001	1.75	1.36	2.13	<.0001
High SES–low SES	0.39	−0.17	0.95	.1483	0.31	−0.23	0.85	.2266
Low SES–high SES	1.58	1.22	1.94	<.0001	1.44	1.04	1.83	<.0001
Low SES–low SES (ref)								
Time	−0.03	−0.08	0.01	.1738	0.11	0.05	0.16	.0009
Time × High SES–high SES	−0.12	−0.22	−0.02	.0231	−0.12	−0.22	−0.01	.0347
Time × High SES–low SES	−0.04	−0.16	−0.07	.4251	−0.03	−0.15	0.09	.5828
Time × low SES–high SES	−0.10	−0.21	0.01	.0677	−0.09	−0.20	0.01	.0848
Demographic factors								
Age at visit					−0.09	−0.10	−0.07	<.0001
Gender (males/females)					−0.67	−0.86	−0.47	<.0001
Generations born in Mexico (0–3)					−0.02	−0.12	0.08	.7238
Health insurance (yes/no)					−0.34	−0.63	−0.05	.0219
Health-related factors								
Diabetes (yes/no)					−0.43	−0.59	−0.26	<.0001
Stroke (yes/no)					−0.48	−0.75	−0.21	.0006
Hypertension (yes/no)					−0.13	−0.29	0.03	.1087

Note: SES = socioeconomic status; SEVLT = Spanish English Verbal Learning Test.

(β = .41, $p = .003$), but addition of adult SES (β = 1.33, $p \leq .0001$) to the model reduced the association between childhood SES and SEVLT by 43% (β = .23, $p = .06$). Because childhood SES was no longer significant, it appears that adult SES mediates the association between early SES and cognitive function in old age.

Table 5 presents the results for two sequential mixed linear models that evaluate the association between cumulative deprivation (CD) score and the SEVLT score as the dependent variable. The number of Mexican-born generations is included as a categorical variable, and interactions test whether the association between CD and SEVLT score is

Table 5. Association between cumulative deprivation (CD) and the SEVLT from two sequential mixed linear models by number of generations born Mexico

	Model 1				Model 2			
	β	Lower Confidence Limit	Upper Confidence Limit	*p* value	β	Lower Confidence Limit	Upper Confidence Limit	*p* value
Intercept	9.89	9.34	10.43	.000	17.22	16.01	18.43	.000
Cumulative	−0.25	−0.32	−0.17	.000	−0.23	−0.33	−0.13	.000
Generations born								
All USA 0 (all)	0.09	−1.26	1.45	.890	−0.06	−1.41	1.28	.922
Mexican 1: (GP)	2.01	0.55	3.48	.008	2.09	0.76	3.43	.002
Mexican 2: (GP + P)	1.06	0.36	1.76	.003	0.72	−0.03	1.48	.061
Mexican 3: (ref)								
Time	−0.03	−0.07	0.02	.198	0.08	0.03	0.13	.004
Generations × CD								
All USA 0 (all) × CD	−0.02	−0.25	0.20	.827	0.01	−0.21	0.23	.939
Mexican 1: (GP) × CD	−0.27	−0.53	−0.01	.044	−0.32	−0.55	−0.09	.007
Mexican 2	−0.12	−0.24	0.00	.044	−0.06	−0.13	0.07	.349
Age at visit					−0.09	−0.11	−0.08	.000
Gender					−0.67	−0.87	−0.47	.000
Health insurance					−0.33	−0.63	−0.03	.034
Health related								
Diabetes (yes/ no)					−0.46	−0.63	−0.30	.000
Stroke (yes/ no)					−0.46	−0.75	−0.18	.001
Hypertension					−0.13	−0.29	0.04	.123

Note: GP = grandparents; P = parents; SEVLT = Spanish English Verbal Learning Test.

modified by the number of generations. Compared with those with all three generations born in Mexico, those with only grandparents (Gen 1) or with grandparents and parents born in Mexico (Gen 2) performed better on the SEVLT. All U.S.–born generations (Gen 0) did not differ from all Mexico–born generations (Gen 3) on the SEVLT. Generations modified the association between cumulative deprivation and SEVLT such that the SEVLT score was lower in Gen 1 or Gen 2 as the number of deprivations increased.

Nativity and migration are important predictors of the life time trajectories of SES, and they modify the relationship of lifetime SES to late life cognitive aging. There is more downward mobility in Gen 0 (22%) and Gen 3 (23%) than in Gen 1 (12%) and Gen 2 (13.5%) and more upward mobility in Gen 1 and Gen 2 than in Gen 0 and Gen 3. The highest level of sustained poverty is in Gen 3 (all Mexico), and the highest level of sustained (relative) affluence is in Gen 0 (all United States). Participants who are immigrants are more likely to remain poor, whereas participants whose parents and/or grandparents are U.S. born more likely to improve in SES. The greater occurrence of downward mobility in the three U.S. generation group of participants may reflect declines in SES seen in more acculturated postimmigrant generations (Duncan & Trejo, 2008).

In this analysis, lifetime SES trajectories have strong overall influence on both global cognitive function and short-term verbal memory such that those who are advantaged in both childhood and adulthood experience fewer declines in global cognition and verbal memory compared with those who are less advantaged. Upward mobility is similarly beneficial for these outcomes. The number of generations since migration to the Unites States also modifies the effects of cumulative deprivation on global cognitive performance and on memory. Compared with Gen 3 participants, CD has more benefit for global cognition in Gen 0, Gen 1, or Gen 2 participants. Verbal memory is more adversely affected by CD in Gen 1 and Gen 2 participants compared with Gen 0 or Gen 3 participants. Importantly, the links between early SES and late life cognitive aging appear to be at least partly mediated by adult SES. This points to a pattern of accumulated deprivation (or improvement), but the influences of upward and downward mobility on cognitive aging suggest that nonlinear patterns are also important.

Discussion

Other studies (Harper et al., 2002; Kaplan et al., 2001; Karlamangla et al., 2009; Kok et al., 2006; Turrell et al., 2002; von Ehrenstein et al., 2009) have reported that lifetime SES is associated with late life cognitive functioning. A recent study of a Chinese birth cohort (Zhang et al., 2009) suggested that early life SES has an association with late life cognitive function that is not explained by markers of early nutritional development. Our results are consistent with these other studies. Although we have little information about early nutritional status (other than reports of sibling mortality and lack of food), we can indirectly infer the quality of the early environment from life expectancy (LE) at birth in Mexico or in the United States during the time period our study participants were born (1899–1939). In 1900, LE at birth in Mexico was about 27 years and in the United States, it was 48 years. By 1938, LE at birth had risen to 39 in Mexico and 62 in the United States. LE at birth is a summary marker of environmental improvements affecting survival in children below 5 years (Johansson, 2008). These LE data suggest that socioenvironmental and health quality in early life for our study participants differed sharply by country of birth. Improvements in LE over the 40 years from 1898 to 1938 suggest that the early environment of younger participants was comparatively better than of older participants. However, comparison of the influence of numbers of generations on late life cognitive aging by birth cohort did not reveal any effect modification.

This study was only able to follow participants from older ages for a maximum of 9 years. As such, data on early life SES are entirely retrospective. Attrition from the cohort due to death may have lead to underestimates of the association between lifetime SES and late life cognitive function, as both early and later life SES are inversely associated with higher mortality. We do not have measures of cognitive ability in early life as some studies have (Luciano et al., 2009). However, those studies have also experienced very substantial attrition across five to six decades and are likely to be biased in their estimates. Health and economic selection are common features of the study of migration and are thought to result in an immigrant population that is at least initially healthier and wealthier than the population remaining in the sending country or than native born in the receiving country. We cannot account for this issue directly here. However, the average length of residence in the United States was 35 years for participants who migrated. The force of migration selection is likely to be weakened over time by adaptation and increasing exposure to the new environment and would have no direct relevance for migration by previous generations (Gen 1 and Gen 2).

This analysis has shown that both early life and midlife SES have individual effects on cognitive aging. The effects on cognitive aging of early SES are partially mediated by midlife SES. We have demonstrated that nativity and migration are related to differences in lifetime SES trajectories. The heterogeneity of cognitive aging trajectories observed among diverse race/ethnic groups may be influenced by intergenerational changes in SES, cultural norms, and behaviors and changes in health related to changes in the social and physical environment. Lifetime trajectories of change in SES may not be linear. The literature on life course suggests that there may be cumulative or "chained" effects of SES and/or that SES exposures in a specific stage, for example, early childhood, may have a major role in late life

cognitive aging. These differences are important in determining when and how to intervene. Our results for upward and downward mobility suggest that modifications in the SES trajectory are possible. Education is a highly modifiable SES factor that is thought to directly affect neurodevelopment and certainly can lead to better jobs and more income. In the United States, there are nearly 46 million U.S. residents who are Hispanic, of whom nearly 30 million were born in Mexico (Pew Hispanic Center, 2010). Of the Mexican ancestry population in the United States, only 28% have a high school diploma, 41% are employed in manual occupations, and 21% are living in poverty. The percent of three-generation U.S.-born families among Mexican Americans increased from 37% to 57% between 1980 and 2007. More than 50% of immigrants from Mexico are unauthorized and are likely to remain in sustained poverty throughout their life span. In fact, the second and third generations postmigration have lower high school graduation rates than other race/ethnic groups. The impact of migration and nativity on lifetime SES trajectories and their effects on cognitive aging are largely unexplored but may have important implications for future population health.

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References

ADA. (2006). Diagnosis and classification of diabetes mellitus. *Diabetes Care*, *29*(Suppl 1). S43–S48.

Association, A. H. (2010), *High blood pressure AHA recommendations.* Retrieved from http://www.americanheart.org/presenter.jhtml?identifier=4623

Beevers, G., Lip, G. Y., & O'Brien, E. (2001). ABC of hypertension. Blood pressure measurement. Part I-sphygmomanometry: Factors common to all techniques. *BMJ*, *322*, 981–985.

Pew Hispanic Center. (2010). Retrieved from http://pewhispanic.org/

Clarke, P., O'Malley, P. M., Johnston, L. D., & Schulenberg, J. E. (2009). Social disparities in BMI trajectories across adulthood by gender, race/ethnicity and lifetime socio-economic position: 1986–2004. *International Journal of Epidemiology*, *38*, 499–509.

Dowd, J. B., Zajacova, A., & Aiello, A. (2009). Early origins of health disparities: Burden of infection, health, and socioeconomic status in U.S. children. *Social Science & Medicine*, *68*, 699–707.

Duncan, B., & Trejo, S. J. (2008). *Intermarriage and the intergenerational transmission of ethnic identity and human capital for Mexican Americans*. CReAM Discussion Paper No 02/09. Centre for Research and Analysis of Migration. London: University College London.

Gonzalez, H. M., Mungas, D., & Haan, M. N. (2002). A verbal learning and memory test for English- and Spanish-speaking older Mexican-American adults. *Clinical Neuropsychologist*, *16*, 439–451.

Gonzalez, H. M., Mungas, D., & Haan, M. N. (2005). A semantic verbal fluency test for English- and Spanish-speaking older Mexican-Americans. *Archives of Clinical Neuropsychology*, *20*, 199–208.

Gonzalez, H. M., Mungas, D., Reed, B. R., Marshall, S., & Haan, M. N. (2001). A new verbal learning and memory test for English- and Spanish-speaking older people. *Journal of the International Neuropsychological Society*, *7*, 544–555.

Haan, M. N., Mungas, D. M., Gonzalez, H. M., Ortiz, T. A., Acharya, A., & Jagust, W. J. (2003). Prevalence of dementia in older latinos: The influence of type 2 diabetes mellitus, stroke and genetic factors. *Journal of the American Geriatrics Society*, *51*, 169–177.

Haas, S., & Rohlfsen, L. (2009). Life course determinants of racial and ethnic disparities in functional health trajectories. *Social Science & Medicine*, *70*, 240–250.

Harper, S., Lynch, J., Hsu, W. L., Everson, S. A., Hillemeier, M. M., Raghunathan, T. E., . . . Kaplan, G. A. (2002). Life course socioeconomic conditions and adult psychosocial functioning. *International Journal of Epidemiology*, *31*, 395–403.

Johansson, K. (2008). Documentation for life expectancy at birth (years) for countries and territories. In Gapminder (Ed.), *Gapminder documentation 004 ver. 3.* Stockholm: Sweden: Gapminder Foundation.

Kaplan, G. A., Turrell, G., Lynch, J. W., Everson, S. A., Helkala, E. L., & Salonen, J. T. (2001). Childhood socioeconomic position and cognitive function in adulthood. *International Journal of Epidemiology*, *30*, 256–263.

Karlamangla, A. S., Miller-Martinez, D., Aneshensel, C. S., Seeman, T. E., Wight, R. G., & Chodosh, J. (2009). Trajectories of cognitive function in late life in the United States: Demographic and socioeconomic predictors. *American Journal of Epidemiology*, *170*, 331–342.

Kok, H. S., Kuh, D., Cooper, R., van der Schouw, Y. T., Grobbee, D. E., Wadsworth, M. E., . . . Richards, M. (2006). Cognitive function across the life course and the menopausal transition in a British birth cohort. *Menopause*, *13*, 19–27.

Luciano, M., Gow, A. J., Harris, S. E., Hayward, C., Allerhand, M., Starr, J. M., . . . Deary, I. J. (2009). Cognitive ability at age 11 and 70 years, information processing speed, and APOE variation: The Lothian Birth Cohort 1936 study. *Psychology and Aging*, *24*, 129–138.

Raghunathan, T. E., Lepkowski, J. M., Hoewyk, J. V., Solenberger, P. (2001). A multivariate technique for multiply imputing missing values using a sequence of regression models. *Survey Methodology*, *27*, 83–95.

Rubin, D. B. (1976). Inference and missing data. *Biometrika*, *63*, 581–590.

Rubin, D. B. (1987). *Multiple imputation for nonresponse in surveys*. New York: John Wiley & Sons.

Teng, E. L., & Chui, H. C. (1987). The Modified Mini-Mental State (3MS) examination. *Journal of Clinical Psychiatry*, *48*, 314–318.

Tombaugh, T. N. (2005). Test-retest reliable coefficients and 5-year change scores for the MMSE and 3MS. *Archives of Clinical Neuropsychology*, *20*, 485–503.

Turrell, G., Lynch, J. W., Kaplan, G. A., Everson, S. A., Helkala, E. L., Kauhanen, J., . . . Salonen, J. T. (2002). Socioeconomic position across the lifecourse and cognitive function in late middle age. *Journal of Gerontology Series B: Social Sciences*, *57*, S43–S51.

von Ehrenstein, O. S., Mikolajczyk, R. T., & Zhang, J. (2009). Timing and trajectories of fetal growth related to cognitive development in childhood. *American Journal of Epidemiology*, *170*, 1388–1395.

Zhang, Z. X., Plassman, B. L., Xu, Q., Zahner, G. E., Wu, B., Gai, M. Y., . . . Xu, T. (2009). Lifespan influences on mid- to late-life cognitive function in a Chinese birth cohort. *Neurology*, *73*, 186–194.