Bilingualism Does Not Alter Cognitive Decline or Dementia Risk Among Spanish-Speaking Immigrants

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Objective: Clinic-based studies suggest that dementia is diagnosed at older ages in bilinguals compared with monolinguals. The current study sought to test this hypothesis in a large, prospective, community-based study of initially nondemented Hispanic immigrants living in a Spanish-speaking enclave of northern Manhattan. ***Method:*** Participants included 1,067 participants in the Washington/Hamilton Heights Inwood Columbia Aging Project (WHICAP) who were tested in Spanish and followed at 18–24 month intervals for up to 23 years. Spanish-English bilingualism was estimated via both self-report and an objective measure of English reading level. Multilevel models for change estimated the independent effects of bilingualism on cognitive decline in 4 domains: episodic memory, language, executive function, and speed. Over the course of the study, 282 participants developed dementia. Cox regression was used to estimate the independent effect of bilingualism on dementia conversion. Covariates included country of origin, gender, education, time spent in the United States, recruitment cohort, and age at enrollment. ***Results:*** Independent of the covariates, bilingualism was associated with better memory and executive function at baseline. However, bilingualism was not independently associated with rates of cognitive decline or dementia conversion. Results were similar whether bilingualism was measured via self-report or an objective test of reading level. ***Conclusions:*** This study does not support a protective effect of bilingualism on age-related cognitive decline or the development of dementia. In this sample of Hispanic immigrants, bilingualism is related to higher initial scores on cognitive tests and higher educational attainment and may not represent a unique source of cognitive reserve.

Keywords: cognitive aging, episodic memory, executive function, language, statistical modeling

Bilingualism has powerful effects on childhood cognitive development and is associated with enhanced executive control,

cognitive flexibility, and theory of mind in children (Akhtar & Menjivar, 2012). These effects may result from extended practice in inhibition (Emmorey, Luk, Pyers, & Bialystok, 2008). Because both languages are activated when one is being used, bilingual individuals must continuously resolve lexical competition via inhibition (e.g., inhibiting the Spanish word *perro* while producing the English word *dog*; Abutalebi & Green, 2008). However, executive function advantages are also reported in preverbal infants in bilingual homes (Kovacs & Mehler, 2009). This observation suggests that practice in inhibition during language expression may not be required for executive function benefits to emerge. Instead, the executive function advantage associated with bilingualism may be linked to domain-general cognitive control processes that are sharpened during the perception of multiple input languages. Hence, noninhibitory cognitive processes involved in managing competing representations of two languages may also strengthen executive skills. Regardless of its source, the executive function advantage among bilinguals may persist into late adulthood and contribute to cognitive reserve (Bialystok, Craik, & Luk, 2012). According to the theory of cognitive reserve, certain life experiences and activities mitigate the impact of brain pathology through the adaptive use of neural networks (Stern, 2002, 2009).

There is evidence for both cognitive advantages and disadvantages in bilingual adults. In the language domain, bilingual adults perform worse on measures of vocabulary (Bialystok & Luk,

2012), picture-naming (Gollan, Fennema-Notestine, Montoya, & Jernigan, 2007; Gollan, Montoya, Fennema-Notestine, & Morris, 2005), word comprehension and production (Ivanova & Costa, 2008; Ransdell & Fischler, 1987), and semantic fluency (Gollan & Ferreira, 2009; Gollan, Montoya, & Werner, 2002; Rosselli et al., 2000). Bilingual disadvantages on language tasks are likely due to increased difficulty in lexical processes, such as the speed of lexical access (i.e., the time required to activate and select a specific word). Because the sizes of bilinguals' lexicons are approximately double those of monolinguals, they have more word options to express a given concept, which increases competition during lexical selection. By necessity, they use each language less frequently than their monolingual counterparts (e.g., Gollan, Montoya, Cera, & Sandoval, 2008). Very few studies have assessed whether the lexical access disadvantage for bilinguals changes with aging, but limited extant evidence suggests that the effects of bilingualism on lexical access are similar for young and older adults (Gollan et al., 2008).

In contrast to those in the language domain, a number of studies have reported superior executive control and episodic memory in bilingual adults compared with monolinguals (Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok, Craik, & Luk, 2008; Salvatierra & Rosselli, 2010; Schroeder & Marian, 2012). Recent functional MRI evidence showed that improved task switching performance among older lifelong bilinguals was associated with attenuation of age-related overrecruitment of left lateral frontal cortex and cingulate cortex (Gold, Johnson, Kryscio, & Smith, 2013). This observation suggests that bilingualism is associated with improved neural efficiency, a key aspect of cognitive reserve. In a recent study, Schroeder and Marian (2012) reported better performance in bilingual versus monolingual older adults on an episodic memory recall task, another cognitive domain that exhibits its robust age-related decline. The authors attributed this effect to the "executive" components of episodic memory performance (i.e., processes required for active encoding and retrieval). Given evidence that bilingualism is associated with better executive control and episodic memory and more efficient neurocognitive processing, it is possible that it may protect against general age-related cognitive decline and dementia.

To date, three clinic-based studies have tested for a relationship between bilingualism and dementia. The first involved a retrospective chart review of 184 patients from a memory clinic in Toronto and reported that bilinguals were diagnosed with dementia an average of 4 years later than monolinguals (Bialystok, Craik, & Freedman, 2007). The second study did not replicate this finding in a sample of 632 patients with probable Alzheimer's disease from a memory clinic in Montreal (Chertkow et al., 2010). That study found only a small protective effect of speaking three or more languages (i.e., multilingualism). The third study, in a sample of 44 Hispanics with probable Alzheimer's disease (AD) at an Alzheimer's disease Research Center in California, reported an association between Spanish-English bilingualism and later age of dementia diagnosis only among patients with low education (≤ 11 years; Gollan, Salmon, Montoya, & Galasko, 2011). Given these discrepant results, a large, prospective, community-based study of the effects of bilingualism on the development of dementia is needed. Unlike previous studies in which monolinguals and bilinguals seen in memory clinics were culturally different, we recruited monolinguals and bilinguals from a single population. This is also the first study to analyze the relationship between bilingualism and incident dementia, rather than prevalent dementia. In contrast, the three studies reviewed above used less reliable estimates of clinical onset for most participants. The current study examines the influence of bilingualism on cognitive decline and dementia conversion among 1,067 initially nondemented Hispanic immigrants followed prospectively up to 23 years.

Method

Participants and Procedure

The 1,067 older Hispanics in this sample were participants in the Washington/Hamilton Heights Inwood Columbia Aging Project (WHICAP). WHICAP is a prospective, community-based longitudinal study of aging and dementia in a racially and ethnically diverse sample of Medicare-eligible residents of northern Manhattan. The community of Washington/Hamilton Heights and Inwood is a Spanish-speaking enclave populated largely by emigrants from the Caribbean.

Descriptions of full study procedures and of the total sample have been reported previously (Manly et al., 2005; Tang et al., 2001). In brief, participants were identified from Medicare records and recruited in two waves: 1992 (N = 627) and 1999 (N = 604). Ongoing follow-up occurs at 18–24 month intervals and includes a battery of cognitive, functional, and health measures administered in the participant's preferred language (English or Spanish). Only 6.6% of Hispanic immigrants in WHICAP prefer to be evaluated in English. A full description of procedures for translating the WHICAP battery into Spanish has been reported previously (Jacobs et al., 1997). In brief, all interview questions, test instructions, and stimuli were first translated into Spanish by a committee of native Spanish speakers from the Dominican Republic, Puerto Rico, Cuba, and Spain. Next, all material was back-translated to ensure accuracy. When necessary, scoring criteria were modified to allow credit to be given for responses reflecting regional idioms. Interviewers of Spanish-speaking participants are fully bilingual community members. Race and ethnicity is determined via self-report using the format of the 2000 U.S. Census. The current sample included only participants who self-identified as Hispanic (of any race), were born outside the United States, were tested in Spanish, had data on self-reported English language proficiency, and did not meet criteria for dementia at their initial study visit. See Dementia Diagnosis for a description of dementia diagnoses in WHICAP. Characteristics of the sample are available in Table 1. These characteristics are presented separately for monolinguals (i.e., participants who answered "not at all" to the English proficiency question) and bilinguals (i.e., participants who answered "not well," "well," or "very well" to the English proficiency question). However, it should be noted that bilingualism was treated as a four-category variable in all analyses, as described below.

Measures

Bilingualism. All participants were born and raised in Spanish-speaking countries, their first language was Spanish, they considered Spanish to be their primary language, and they chose to be evaluated in Spanish for the WHICAP study. In addition, the

Table 1
Sample Characteristics

	Monolinguals[a] (N = 637)		Bilinguals (N = 430)		
	Mean (*SD*)	Range	Mean (*SD*)	Range	*p*
Baseline age	75.66 (5.79)	64–95	74.78 (5.66)	64–94	.01
Education	5.05 (3.61)	0–18	8.30 (4.22)	0–20	<.001
Gender (% female)	72	—	64	—	.01
Country of origin (%)					<.001
Dominican Republic	74	—	29	—	
Puerto Rico	4	—	31	—	
Other	22	—	40	—	
Age of immigration to the United States	48.23 (11.09)	15–80	34.22 (11.97)	4–86	<.001
Executive function	−0.14 (0.69)	−2.05–2.18	0.32 (0.75)	−2.39–2.44	<.001
Memory	−0.10 (0.80)	−3.60–2.45	0.19 (0.83)	−2.48–2.25	<.001
Language	−0.11 (0.73)	−3.14–0.99	0.27 (0.60)	−2.12–0.99	<.001
Speed	0.04 (0.82)	−2.08–1.62	−0.25 (0.81)	−1.95–1.62	<.001
Task switching	0.01 (0.98)	−2.21–2.16	−0.01 (1.03)	−3.05–1.86	.90
Length of follow-up in years	6.62 (4.66)	0–23	6.14 (4.75)	0–22	.11
Number of assessments	3.67 (1.94)	1–12	3.57 (1.98)	1–12	.39
Percent with incident dementia	31	—	20	—	<.001
Probable Alzheimer's disease	64	—	61	—	
Alzheimer's with concomitant disease[b]	13	—	17	—	
Alzheimer's with stroke	13	—	14	—	
Alzheimer's with Parkinson's	2	—	4	—	
Vascular dementia	3	—	1	—	
Dementia with Lewy bodies	1	—	1	—	
Other	4	—	2	—	

[a] Here, monolinguals are defined as participants who answered "not at all" to the English proficiency question. [b] Other concomitant diseases include major depression, traumatic brain injury, etc.

interviewer confirmed that participants demonstrated fluency in Spanish throughout the interview. Level of bilingualism in this cohort was therefore classified based on English language proficiency. Proficiency in English was characterized via self-report using a 4-point Likert-type item that asked, "How well do you speak English?" Of the 1,067 participants who completed this item, 47 (4%) reported speaking English "very well;" 106 (10%) "well;" 277 (26%) "not well;" and 637 (60%) "not at all." The validity of this self-report item was assessed with the English-language Wide Range Achievement Test–Version 3 (WRAT-3; Wilkinson, 1993) in a subgroup of 235 participants. The average WRAT-3 score in this subgroup was 17.31 (*SD* = 16.91; range: 0–53). A one-way analysis of variance confirmed that English reading level was positively associated with self-reported English proficiency, $F(3, 229) = 57.17$; $p < .001$. Tukey's honest significant difference further demonstrated that individuals reporting no English proficiency performed significantly worse on the WRAT-3 compared with the other three groups (all p's < .001). Individuals who reported speaking English "not well" performed significantly worse than those who reported speaking English "well" ($p = .001$) or "very well" ($p = .008$). There was no significant difference in WRAT-3 performance between those who reported speaking English "well" versus "very well" ($p = .999$).

Memory. Episodic memory was assessed with the Selective Reminding Test (SRT; Buschke & Fuld, 1974). Participants are given six trials to learn a list of 12 words. Following each trial, participants are only reminded of the words they failed to recall. Total learning is quantified as the total number of words recalled after the six learning trials. Delayed recall is quantified as the number of words recalled after a 15-min delay. Delayed recogni-

tion is the number of words correctly recognized immediately following the delayed recall trial. Total learning, delayed recall, and delayed recognition scores at each occasion were standardized to *z*-score metric using the sample's means and standard deviations at the initial occasion. Memory composite scores for each occasion were computed by averaging the three *z*-scores at that occasion.

Language. Language was assessed with tests of naming, repetition, and comprehension. Naming ability was quantified as the number of spontaneously identified objects on a 15-item version of the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983). Repetition and comprehension were assessed with subtests of the Boston Diagnostic Aphasia Examination (Goodglass, 1983). Repetition was quantified as the total number of high-probability phrases correctly repeated. Comprehension was quantified as the total number of correct responses to comprehension questions. Naming, repetition, and comprehension scores at each occasion were standardized to *z*-score metric using the sample's means and standard deviations at the initial occasion. Language composite scores for each occasion were computed by averaging the three *z*-scores at that occasion.

Executive functions. Executive functions were assessed with tests of verbal and nonverbal abstraction and letter fluency. Verbal abstraction was quantified as the total raw score on the Similarities subtest of the Wechsler Adult Intelligence Scale–Revised (Wechsler, 1981). Nonverbal abstraction was quantified as the total score on the Identities and Oddities subtest of the Mattis Dementia Rating Scale (Mattis, 1976). Letter fluency was quantified as the total number of words beginning with P, S, or V generated over three 60-s trials. Verbal abstraction, nonverbal abstraction, and letter fluency scores at each occasion were stan-

dardized to *z*-score metric using the sample's means and standard deviations at the initial occasion. Executive function composite scores for each occasion were computed by averaging the three *z*-scores at that occasion.

Task switching, an aspect of executive functions that may more closely resemble the demands of bilingualism, was assessed in a subset of 396 participants (233 monolinguals and 163 bilinguals) with the Color Trails Test. All of these participants were from the second recruitment wave (1999), when the Color Trails Test was added to the WHICAP battery. In Trial 1, participants sequence numbers. In Trial 2, participants sequence numbers while simultaneously alternating between two colors. Trial 1 and 2 scores were the number of seconds taken to complete the trial (maximum: 240 s). Task switching was quantified as the residual variance in Trial 2 scores after regressing Trial 2 scores onto Trial 1 scores (Salthouse, 2011). These residualized Trial 2 scores were standardized to *z*-score metric using the sample's means and standard deviations at the initial occasion. Because this task-switching variable was only available on a subset of participants, it was not included in the executive function composite score described above.

Speed. Speed was assessed in a subset of 396 participants with the Color Trails Test (described above). All of these participants were from the second recruitment wave (1999). Trial 1 and 2 scores at each occasion were standardized to z-score metric using the sample's means and standard deviations at the initial occasion. Speed composite scores for each occasion were computed by averaging the two *z*-scores at that occasion.

Dementia Diagnosis

As shown in Table 1, 282 participants developed dementia over the course of the study. Dementia diagnoses based on *DSM–III* criteria were made after each follow-up visit by a consensus group of neurologists, psychiatrists, and neuropsychologists based on information gathered at that visit, and blind to scores and diagnoses at prior visits. The cause of dementia was determined using published research criteria for probable and possible AD (McKhann et al., 1984), vascular dementia (Roman et al., 1993), Lewy body dementia (McKeith et al., 1996), and other dementias.

Statistical Analysis

The primary aims of this study were to evaluate associations between (a) self-reported and (b) objectively measured bilingualism, and (1) cognitive trajectories within four domains and (2) dementia conversion. Descriptive statistics were computed using SPSS version 20. Multilevel modeling and survival analyses (described below) were conducted in Mplus version 7.

Associations between bilingualism and cognitive trajectories (Aim 1) were explored via the multilevel model for change. Modeling proceeded in three broad stages. First, longitudinal changes within each of the four cognitive domains (i.e., executive function, memory, language, and speed) were characterized via four *unconditional growth models*, which included no covariates. These unconditional models provided estimates of overall initial scores on the cognitive composites and linear rates of change over the 23-year study period. The relationship between bilingualism and longitudinal changes in task-switching ability were analyzed in a subset of 396 participants from the second recruitment wave

(1999) who completed the Color Trails Test. The time variable in all growth models was age.

Next, the general relationship between degree of bilingualism and cognitive trajectories was examined by adding a four-category variable representing participants' self-reported English language proficiency to the four unconditional growth models. These *unadjusted conditional models* provided estimates of general relationships between bilingualism and the cognitive trajectories, without taking into account other covariates.

Finally, five covariates were added to the four unadjusted models. Covariates were chosen based on the extant literature and findings of univariate relationships with variables of interest within the present sample. Covariates were centered in order to facilitate parameter interpretation. Specifically, values of 0 correspond to country of origin other than Puerto Rico or Dominican Republic, male gender, 6 years of education, 41% of life spent in the United States, and recruitment in 1992. Positive values of these variables correspond to country of origin of Puerto Rico or Dominican Republic, female gender, more education, higher proportion of life spent in the United States, and recruitment in 1999. These *adjusted conditional models* provided estimates of unique relationships between bilingualism and the cognitive trajectories.

The influence of bilingualism on dementia conversion (Aim 2) was explored with Cox regression. The time variable was defined as the time in years from first assessment to the first assessment at which a diagnosis of dementia was assigned via consensus (see Dementia Diagnosis). Separate Cox models were run with and without covariates, including age at enrollment.

In order to explore whether an objective measure of bilingualism was associated with cognitive trajectories or dementia conversion, all adjusted growth and Cox models described above were rerun on a subset of 235 participants who had completed the WRAT-3, substituting WRAT-3 scores for self-reported English language proficiency.

Results

Cognitive Trajectories

Cognitive domains. First, unconditional growth models were run in order to characterize trajectories of change within the four cognitive domains. Estimated initial scores and rates of change in these models are shown separately for the four cognitive domains in Table 2. Slope estimates were significant for all four domains, indicating that performance declined over time. Slope means shown in Table 2 correspond with the annual rates of change in each domain. Specifically, on average, participants scored between .012 and .069 points worse on the *z*-score composites each year.

Next, self-reported bilingualism at baseline was added to the four growth models as a covariate. Greater level of bilingualism was associated with better initial performance on all four cognitive composites. Specifically, each incremental increase in self-reported bilingualism corresponded to 0.282 more points on the executive function composite ($p < .001$), 0.166 more points on the memory composite ($p < .001$), 0.189 more points on the language composite ($p < .001$), and 0.250 fewer points on the speed composite ($p < .001$). However, degree of bilingualism was not associated with rates of change in any of the four cognitive

Table 2
Unstandardized Parameter Estimates in the Unconditional Models

	Initial level				Slope			
	Mean	SE	Variance	SE	Mean	SE	Variance	SE
Executive function	0.078	0.023	0.397	0.022	−0.012	0.002	0.001	0.000
Memory	−0.072	0.025	0.446	0.028	−0.069	0.003	0.002	0.000
Language	0.055	0.023	0.278	0.017	−0.025	0.002	0.001	0.000
Speed[a]	−0.034	0.038	0.340	0.046	0.059	0.005	0.001	0.001

Note. Unconditional models do not contain covariates. *SE* = standard error.
[a] Lower values on the speed composite indicate better performance.

domains. In other words, cognitive function of bilinguals and monolinguals declined at the same rate over time.

In addition to level of bilingualism, the following covariates were next added to the four growth models: country of origin, gender, years of education, proportion of time spent in the United States, and recruitment wave. Associations between the six covariates (including degree of bilingualism) and the cognitive trajectories are shown in Table 3. After controlling for the added covariates, higher level of bilingualism remained associated with better initial scores on the executive functioning and memory composites, but not on the language or speed composites. Again, degree of bilingualism was not associated with the rate of change in any cognitive domain.

Isolating task switching. Because of its special emphasis within prior research on cognitive function among bilinguals, we ran separate analyses using task switching as the outcome. An adjusted conditional model was run using standardized residualized Color Trails Test Trial 2 scores (see Executive functions) as the dependent variable. In this model, self-reported level of bilingualism was not independently related to initial task-switching ability or rate of change in task-switching ability.

Dementia Conversion

First, the influence of bilingualism on dementia conversion was estimated without covariates. In this initial model, better self-rated bilingualism was associated with lower odds of dementia conversion. Specifically, each point on the self-report scale was associated with 0.291 lower log odds of conversion to dementia.

Next, the five covariates described above and age at enrollment were added to the model. Of the seven total variables included, only female gender, age at enrollment, and years of education were significantly associated with dementia conversion. Specifically, being female was associated with 0.338 lower log odds of conversion ($p = .019$). Each year of age past 75 was associated with 0.110 higher log odds of conversion ($p < .001$). Each year of education past 6 was associated with 0.054 lower log odds of conversion ($p = .007$). Figure 1 displays survival curves from the adjusted model estimated separately for various levels of bilingualism and the three variables found to be significantly associated with dementia conversion (i.e., female, age at enrollment, and education). As shown, wider separation between estimated survival curves is seen for gender, age and education, as compared with degree of bilingualism. This pattern of results was virtually identical when the 23 individuals who converted to a non-AD or unknown cause of dementia were excluded from the analysis.

Because the association between bilingualism and dementia conversion was nonsignificant in the adjusted model, results from tests of relationships between bilingualism and the relevant covariates are presented. There was no systematic relationship between bilingualism and age. Males reported a greater degree of bilingualism than females, $\chi^2(3) = 9.566$; $p = .023$. A greater degree of bilingualism was associated with higher educational attainment, $F(3, 1075) = 92.783$; $p < .001$. Tukey's honest significant difference revealed that each increase in degree of bilingualism was associated with a nonmonotonic increase in years of education, with the exception that participants who reported speaking English

Table 3
Covariate Effects on Cognitive Trajectories

	Executive function		Memory		Language		Speed[a]	
	Initial level	Slope	Initial level	Slope	Initial level	Slope	Initial level	Slope
Born in PR/DR	−0.05 (0.04)	—	−0.15 (0.06)[*]	—	−0.12 (0.04)[*]	—	0.25 (0.09)[*]	—
Female gender	−0.08 (0.04)	—	0.26 (0.06)[*]	—	0.03 (0.04)	—	0.06 (0.08)	—
Education	0.08 (0.01)[*]	—	0.03 (0.01)[*]	—	0.05 (0.01)	—	−0.05 (0.01)	—
Time in U.S.	−0.08 (0.15)	0.01 (0.02)	0.01 (0.18)	−0.03 (0.02)	0.41 (0.14)[*]	—	−0.70 (0.25)	−0.03 (0.04)
1999 wave	−0.06 (0.04)	0.02 (0.01)[*]	−0.24 (0.05)[*]	0.02 (0.01)[*]	—	0.01 (0.00)	0.23 (0.13)	−0.03 (0.01)
Bilingualism[b]	−0.12 (0.03)[*]	—	−0.12 (0.04)[*]	−0.01 (0.00)	−0.04 (0.03)	—	0.06 (0.06)	—

Note. Values reflect unstandardized parameter estimates (standard error). For clarity, parameter estimates less than 0.005 are shown as hyphens. PR/DR = Puerto Rico or Dominican Republic; U.S. = United States.
[a] Lower values on the speed composite indicate better performance. [b] Higher values indicated worse self-reported bilingualism.
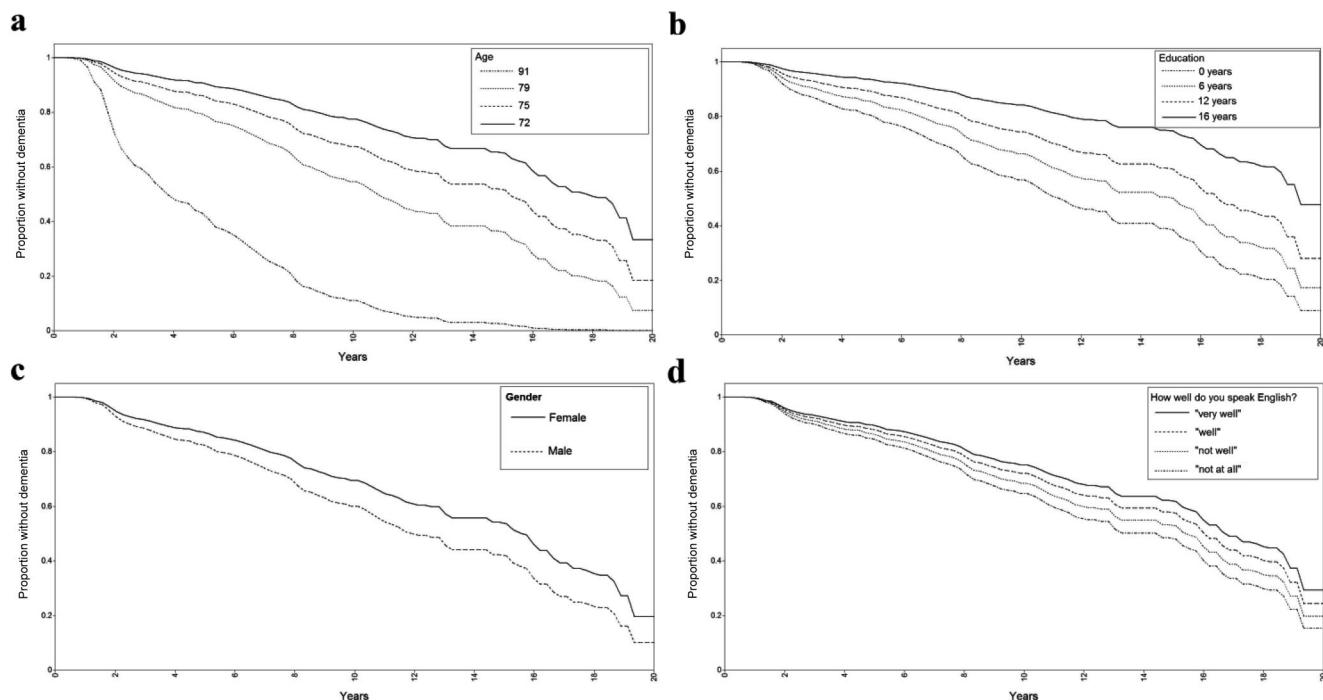[*] $p < .01$.

Figure 1. Estimated survival curves by (a) age, (b) education, (c) gender, and (d) degree of bilingualism in the adjusted Cox regression model. In each panel, curves are estimated with all other covariates held to the sample mean.

"very well" did not significantly differ from participants who reported speaking English "well."

Subjective Versus Objective Bilingualism

The pattern of results for the objective measure of bilingualism was virtually identical to that described above for the self-report variable. Independent of the covariates described above, higher WRAT-3 scores were associated with better initial scores on the executive function and memory composites and on the measure of task switching. Specifically, each point above 17 on the WRAT-3 was associated with 0.012 more points on the executive function composite ($p < .001$), 0.015 more points on the memory composite ($p < .001$), and .011 fewer points on the measure of task-switching. WRAT-3 scores were not independently associated with initial scores on the language or speed composites, rates of cognitive decline, or dementia conversion.

Discussion

Results from this study indicate that native Spanish speaking immigrants to the United States who became bilingual by learning English as adults are not protected against age-related cognitive decline or the development of dementia above and beyond other, related variables (e.g., education). Specifically, neither self-reported English proficiency nor objectively measured English reading level was associated with dementia conversion or rates of decline in episodic memory, language, executive function, speed, or task switching in this sample. Independent of covariates, bilingualism (subjective or objective) was only associated with higher

initial performance on tests of memory and executive function. Additionally, an objective measure of English reading level was associated with better initial task-switching ability. The dementia incidence rate (i.e., 26% over 23 years) is comparable with rates observed in other longitudinal studies with similar amounts of follow-up (Rocca et al., 2011; Saczynski et al., 2010).

These findings concur with the results of the largest clinic-based study examining the influence of bilingualism on dementia, which found no difference in age of AD diagnosis among bilingual and monolingual patients at a memory clinic in Montreal (Chertkow et al., 2010). The current study extends these findings to a much larger, community-based sample in the United States and uses a cleaner sample of incident dementia cases. The present results are also in line with two community-based studies that reported no relationship between dementia conversion and constructs closely related to bilingualism. Crane et al. (2009) reported no protective effect of self-reported use of written Japanese in midlife on later dementia risk among Japanese American men born and educated in the United States. Sanders, Hall, Katz, and Lipton (2012) found no difference in dementia risk between native and non-native English speakers, though this study did not assess for potential bilingualism among native English speakers (78% of the sample). It is unclear whether the present results are in line with those of Gollan, Salmon, Montoya, and Galasko (2011). Although those authors reported a significant correlation between degree of bilingualism and age of dementia diagnosis among a subgroup of 22 Hispanics, they do not indicate whether this association remained significant after controlling for education, which ranged from 2 to 11 years, in this small subgroup.

Our results do not support the findings of a smaller, clinic-based study in Toronto (Bialystok et al., 2007). Several shortcomings of this previous report warrant mention. First, age of dementia diagnosis was determined via retrospective chart review based on patient and family recollection of symptom onset as documented in neurologists' notes. In the present study, age of dementia diagnosis was determined prospectively via comprehensive neuropsychological evaluation and expert consensus. Second, quantitative data on the degree of bilingualism were not available. In the present study, degree of bilingualism in English was quantified via self-report and an objective reading level measure. Third, amount of formal education was lower in bilinguals than monolinguals, but the comparability of the education variable between bilinguals educated outside of Canada and monolinguals is unknown. In our sample, we controlled for not only years of formal education, but also country of origin in order to better control for differences in educational quality. Fourth, bilingual status was confounded by immigration status, and analyses did not control for race and ethnicity. Importantly, in the present study of Hispanic immigrants, analyses controlled for both country of origin and proportion of time spent in the United States, because both variables were associated with bilingualism and cognition. It should be noted that the populations under study vastly differ across research groups. The 93 bilinguals studied by Bialystok et al. spoke 25 different languages, and many were bilingual *before* emigrating from their native countries. Spanish was the primary language spoken by participants in the present study, who generally learned English after emigrating primarily from the Caribbean (Dominican Republic, Puerto Rico, and Cuba). Patients studied by Gollan et al. (2011) were mostly Mexican American immigrants, whose culture, immigration history and pressures, and educational environment are considerably different than those of the northern Manhattan-dwelling Caribbean Hispanics.

Bilinguals in the present study exhibited higher initial levels of executive functioning and episodic memory than monolinguals, even after controlling for gender, country of origin, education, and time spent in the United States. These findings are in line with previous reports that bilingual adults exhibit superior executive control and visual episodic memory (Bialystok et al., 2004, 2008; Salvatierra & Rosselli, 2010; Schroeder & Marian, 2012). This is the first study to report a bilingual advantage in verbal episodic memory among older adults. Bilinguals' better episodic memory performance may be tied to their superior executive function abilities, specifically, the control processes needed to selectively encode, organize, and retrieve words. In support of this idea, bilinguals show enhanced inhibition of lexical competitors relative to monolinguals when retrieving words from semantic memory (Blumenfeld & Marian, 2011; Kaushanskaya, Blumenfeld, & Marian, 2011). However, not one of these cross-sectional findings can demonstrate whether bilingualism *imparted* these superior skills. It is possible that better executive and memory skills facilitated the acquisition of a second language. Indeed, we found that these superior cognitive abilities did not translate into protection from age-related decline in these abilities over time.

Several important strengths of this study represent improvements over prior work. First, participants were followed prospectively over 23 years to ensure high-quality information on incident dementia. Many previous studies have relied on retrospective estimates of dementia onset, which are often inaccurate. Second, the sample was recruited from among Medicare-eligible residents of a racially and ethnically diverse area, making it much more representative of older adults in the community than samples recruited from clinics or volunteer populations. Third, the sample is the largest used to assess the influence of bilingualism on the development of dementia. Fourth, complementary longitudinal methods were employed in order to comprehensively examine the influence of bilingualism not only on the development of dementia, but also on changes in multiple cognitive domains. Fifth, all analyses carefully controlled for potential confounding variables that were related to the outcomes. Finally, results for self-reported bilingualism were validated with an objective measure of reading level.

There are several factors that might influence the relationship between bilingualism and cognitive aging that were not considered in the current study. An important variable of interest is bilinguals' degree of engagement in their second language. If executive function benefits rely on extended practice in inhibition, as proposed by Emmorey, Luk, Pyers, and Bialystok (2008), then protective effects of bilingualism on aging might only emerge in those who actively use both languages in their daily lives (e.g., speak one language at home and another at work). Although we expected this to be reflected in the English reading level measure, future studies should explicitly assess how often and in what settings each language is used. A related variable that might influence the bilingualism-cognition link is the age at which the second language was acquired. For example, inhibitory demands might be greater in late-onset bilinguals compared with lifelong bilinguals because their first language has already achieved dominance by the time they learn their second language. As such, it may be more difficult to repress their dominant language during the production and comprehension of their second language, resulting in more intense practice in inhibition. If the amount, rather than the intensity, of practice is the primary contributor to executive function benefits, then lifelong bilinguals may have more of an executive control advantage. In support of this idea, Schroeder and Marian (2012) found that earlier second language acquisition and longer experience with the second language were associated with higher visual episodic memory performance among bilinguals. Most of the participants in our study acquired English upon arriving in the United States, and we adjusted for age at immigration. However, we did not explicitly ask when each participant began to learn their second language.

Standardization of measures of bilingualism (subjective and objective) across studies would improve comparability among results. Measurement of bilingualism is particularly complex in cognitive-impaired older adults, whose second language abilities may deteriorate with the progression of neurodegenerative changes. Importantly, future studies should also explore whether the degree of typological similarity between a bilingual's two spoken languages exerts distinct effects on age-related cognitive decline. There is evidence that different language pairs lead to distinct cognitive profiles among bilinguals due to differing cross-linguistic interference (Kormi-Nouri et al., 2008; Loizou & Stuart, 2003). Knowledge of a second language's syntactic, phonologic, and orthographic structures influences how one processes the other language. Factors such as typological similarity between languages and the type of languages spoken in a community influence the amount of interference from the second language (Serratrice, Sor-

ace, Filiaci, & Baldo, 2009). Although the effects of language similarity on bilinguals' executive control processes have not been directly examined, it is possible that the added cognitive burden of maintaining two orthographically and phonemically disparate languages (e.g., English and Japanese or Korean) may confer better protection from cognitive decline relative to two more structurally similar languages (e.g., Spanish and English). In other words, it is possible that the executive challenge of switching between English and Spanish is not enough to impart changes significant enough to protect against cognitive decline and dementia. Broadly, it should be noted that because of the nature of our cohort and potential specificity of cognitive effects of bilingualism in different languages, we believe that our results should only be generalized to Spanish-speaking immigrants who learn English as adults.

Importantly, the protective effect of bilingualism on dementia conversion identified in an unadjusted model was accounted for by other, related differences between monolinguals and bilinguals (e.g., educational attainment, country of origin, age of immigration). Future studies of bilingualism should carefully control for these and other variables that may influence dementia risk. Bilinguals differ from monolinguals in more than just language use and language learning. Educational background, socioeconomic status, immigration history, and cultural factors are important to consider.

In conclusion, results from this large, prospective, community-based study do not support a protective effect of bilingualism on cognitive decline or the development of dementia among older Spanish-English speakers. Rather, these longitudinal data show that Spanish-speaking immigrants who acquire English as a second language during adulthood exhibit better baseline performance on certain cognitive tasks than those who do not. As a result of the lack of evidence for differences in longitudinal change, it cannot be ruled out that better longstanding executive and memory skills facilitated the acquisition of a second language in this sample. A bilingual advantage in cognitive aging may reflect premorbid capabilities and/or a higher quality of educational experience.

References

Abutalebi, J., & Green, D. W. (2008). Control mechanisms in bilingual language production: Neural evidence from language switching studies. *Language and Cognitive Processes, 23,* 557–582. doi:10.1080/01690960801920602

Akhtar, N., & Menjivar, J. A. (2012). Cognitive and linguistic correlates of early exposure to more than one language. *Advances in Child Development and Behavior, 42,* 41–78. doi:10.1016/B978-0-12-394388-0.00002-2

Bialystok, E., Craik, F. I. M., & Freedman, M. (2007). Bilingualism as a protection against the onset of symptoms of dementia. *Neuropsychologia, 45,* 459–464. doi:10.1016/j.neuropsychologia.2006.10.009

Bialystok, E., Craik, F. I., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: Evidence from the Simon task. *Psychology and Aging, 19,* 290–303. doi:10.1037/0882-7974.19.2.290

Bialystok, E., Craik, F. I. M., & Luk, G. (2008). Lexical access in bilinguals: Effects of vocabulary size and executive control. *Journal of Neurolinguistics, 21,* 522–538. doi:10.1016/j.jneuroling.2007.07.001

Bialystok, E., Craik, F. I. M., & Luk, G. (2012). Bilingualism: Consequences for mind and brain. *Trends in Cognitive Science, 16,* 240–250. doi:10.1016/j.tics.2012.03.001

Bialystok, E., & Luk, G. (2012). Receptive vocabulary differences in monolingual and bilingual adults. *Bilingualism: Language and Cognition, 15,* 397–401. doi:10.1017/S136672891100040X

Blumenfeld, H. K., & Marian, V. (2011). Bilingualism influences inhibitory control in auditory comprehension. *Cognition, 118,* 245–257. doi:10.1016/j.cognition.2010.10.012

Buschke, H., & Fuld, P. A. (1974). Evaluating storage, retention, and retrieval in disordered memory and learning. *Neurology, 24,* 1019–1025. doi:10.1212/WNL.24.11.1019

Chertkow, H., Whitehead, V., Phillips, N., Wolfson, C., Atherton, J., & Bergman, H. (2010). Multilingualism (but not always bilingualism) delays the onset of Alzheimer disease: Evidence from a bilingual community. *Alzheimer Disease & Associated Disorders, 24,* 118–125. doi:10.1097/WAD.0b013e3181ca1221

Crane, P. K., Gibbons, L. E., Arani, K., Nguyen, V., Rhoads, K., McCurry, S. M., . . . White, L. (2009). Midlife use of written Japanese and protection from late life dementia. *Epidemiology, 20,* 766–774. doi:10.1097/EDE.0b013e3181b09332

Emmorey, K., Luk, G., Pyers, J. E., & Bialystok, E. (2008). The source of enhanced cognitive control in bilinguals. *Psychological Science, 19,* 1201–1206. doi:10.1111/j.1467-9280.2008.02224.x

Gold, B. T., Kim, C., Johnson, N. F., Kryscio, R. J., & Smith, C. D. (2013). Lifelong bilingualism maintains neural efficiency for cognitive control in aging. *The Journal of Neuroscience, 33,* 387–396. doi:10.1523/JNEUROSCI.3837-12.2013

Gollan, T. H., Fennema-Notestine, C., Montoya, R. I., & Jernigan, T. L. (2007). The bilingual effect on Boston Naming Test performance. *Journal of the International Neuropsychological Society, 13,* 197–208.

Gollan, T. H., & Ferreira, V. S. (2009). Should I stay or should I switch? A cost-benefit analysis of voluntary language switching in young and aging bilinguals. *Journal of Experimental Psychology Learning, Memory, and Cognition, 35,* 640–665. doi:10.1037/a0014981

Gollan, T. H., Montoya, R. I., Cera, C. M., & Sandoval, T. C. (2008). More use almost always means smaller a frequency effect: Aging, bilingualism, and the weaker links hypothesis. *Journal of Memory and Language, 58,* 787–814. doi:10.1016/j.jml.2007.07.001

Gollan, T. H., Montoya, R. I., Fennema-Notestine, C., & Morris, S. K. (2005). Bilingualism affects picture naming but not picture classification. *Memory & Cognition, 33,* 1220–1234. doi:10.3758/BF03193224

Gollan, T. H., Montoya, R. I., & Werner, G. A. (2002). Semantic and letter fluency in Spanish-English bilinguals. *Neuropsychology, 16,* 562–576. doi:10.1037/0894-4105.16.4.562

Gollan, T. H., Salmon, D. P., Montoya, R. I., & Galasko, D. R. (2011). Degree of bilingualism predicts age of diagnosis of Alzheimer's disease in low-education but not in highly educated Hispanics. *Neuropsychologia, 49,* 3826–3830. doi:10.1016/j.neuropsychologia.2011.09.041

Goodglass, H. (1983). *The assessment of aphasia and related disorders* (2nd ed.). Philadelphia, PA: Lea & Febiger.

Ivanova, I., & Costa, A. (2008). Does bilingualism hamper lexical access in speech production? *Acta Psychologica, 127,* 277–288. doi:10.1016/j.actpsy.2007.06.003

Jacobs, D. M., Sano, M., Albert, S., Schofield, P., Dooneief, G., & Stern, Y. (1997). Cross-cultural neuropsychological assessment: A comparison of randomly selected, demographically matched cohorts of English- and Spanish-speaking older adults. *Journal of Clinical and Experimental Neuropsychology, 19,* 331–339. doi:10.1080/01688639708403862

Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *The Boston Naming Test*. Philadelphia, PA: Lea & Febiger.

Kaushanskaya, M., Blumenfeld, H. K., & Marian, V. (2011). The relationship between vocabulary and short-term memory measures in monolingual and bilingual speakers. *International Journal of Bilingualism, 15,* 408–425. doi:10.1177/1367006911403201

Kormi-Nouri, R., Shojaei, R-S., Moniri, S., Gholami, A. R., Akbari-Zardkhaneh, S., & Nilsson, L.-G. (2008). The effect of childhood bilingualism on episodic and semantic memory tasks. *Scandinavian Journal of Psychology, 49,* 93–109. doi:10.1111/j.1467-9450.2008.00633.x

Kovacs, A. M., & Mehler, J. (2009). Cognitive gains in 7-month old bilingual infants. *Proceedings of the National Academy of Sciences of the United States of America, 106,* 6556–6560. doi:10.1073/pnas.0811323106

Loizou, M., & Stuart, M. (2003). Phonological awareness in monolingual and bilingual English and Greek five-year-olds. *Journal of Research on Reading, 26,* 3–18. doi:10.1111/1467-9817.261002

Manly, J. J., Bell-McGinty, S., Tang, M. X., Schupf, N., Stern, Y., & Mayeux, R. (2005). Implementing diagnostic criteria and estimating frequency of mild cognitive impairment in an urban community. *Archives of Neurology, 62,* 1739–1746. doi:10.1001/archneur.62.11.1739

Mattis, S. (1976). *Mental status examination for organic mental syndrome in the elderly patient.* New York, NY: Grune & Stratton.

McKeith, I. G., Galasko, D., Kosaka, K., Perry, E. K., Dickson, D. W., Hansen, L. A., . . . Perry, R. H. (1996). Consensus guidelines for the clinical and pathological diagnosis of dementia with Lewy bodies (DLB): report of the Consortium on DLB International Workshop. *Neurology, 47,* 1113–1124. doi:10.1212/WNL.47.5.1113

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA Work Group under the auspices of the Department of Health and Human Services Task Force on Alzheimer's disease. *Neurology, 34,* 939–944. doi:10.1212/WNL.34.7.939

Ransdell, S. E., & Fischler, I. (1987). Memory in a monolingual mode: When are bilinguals at a disadvantage? *Journal of Memory and Language, 26,* 392–405. doi:10.1016/0749-596X(87)90098-2

Rocca, W. A., Petersen, R. C., Knopman, D. S., Hebert, L. E., Evans, D. A., Hall, K. S., . . . White, L. R. (2011). Trends in the incidence and prevalence of Alzheimer's disease, dementia, and cognitive impairment in the United States. *Alzheimer's and Dementia, 7,* 80–93. doi:10.1016/j.jalz.2010.11.002

Roman, G. C., Tatemichi, T. K., Erkinjuntti, T., Cummings, J. L., Masdeu, J. C., Garcia, J. H., . . . Jofman, A. (1993). Vascular dementia: Diagnostic criteria for research studies: Report of the NINDS-AIREN International Workshop. *Neurology, 43,* 250–260. doi:10.1212/WNL.43.2.250

Rosselli, M., Ardila, A., Araujo, K., Weekes, V. A., Caracciolo, V., Padilla, M., & Ostrosky-Solís, F. (2000). Verbal fluency and repetition skills in healthy older Spanish-English bilinguals. *Applied Neuropsychology, 7,* 17–24. doi:10.1207/S15324826AN0701_3

Saczynski, J. S., Beiser, A., Seshadri, S., Auerbach, S., Wolf, P. A., & Au, R. (2010). Depressive symptoms and risk of dementia: The Framingham Heart Study. *Neurology, 75,* 35–41. doi:10.1212/WNL.0b013e3181e62138

Salthouse, T. A. (2011). What cognitive abilities are involved in trail-making performance? *Intelligence, 39,* 222–232. doi:10.1016/j.intell.2011.03.001

Salvatierra, J. L., & Rosselli, M. (2010). The effect of bilingualism and age on inhibitory control. *International Journal of Bilingualism, 15,* 26–37. doi:10.1177/1367006910371021

Sanders, A. E., Hall, C. B., Katz, M. J., & Lipton, R. B. (2012). Non-native language use and risk of incident dementia in the elderly. *Journal of Alzheimer's Disease, 29,* 99–108.

Schroeder, S. R., & Marian, V. (2012). A bilingual advantage for episodic memory in older adults. *Journal of Cognitive Psychology, 24,* 591–601. doi:10.1080/20445911.2012.669367

Serratrice, L., Sorace, A., Filiaci, F., & Baldo, M. (2009). Bilingual children's sensitivity to and specificity and genericity: Evidence from metalinguistic awareness. *Bilingualism: Language and Cognition, 12,* 239–257. doi:10.1017/S1366728909004027

Stern, Y. (2002). What is cognitive reserve? Theory and research application of the reserve concept. *Journal of the International Neuropsychological Society, 8,* 448–460. doi:10.1017/S1355617702813248

Stern, Y. (2009). Cognitive reserve. *Neuropsychologia, 47,* 2015–2028. doi:10.1016/j.neuropsychologia.2009.03.004

Tang, M.-X., Cross, P., Andrews, H., Jacobs, D. M., Small, S., Bell, K., . . . Mayeux, R. (2001). Incidence of AD in African-Americans, Caribbean Hispanics, and Caucasians in northern Manhattan. *Neurology, 56,* 49–56. doi:10.1212/WNL.56.1.49

Wechsler, D. (1981). *Wechsler Adult Intelligence Scale-Revised.* New York, NY: The Psychological Corporation.

Wilkinson, G. S. (1993). *Wide range achievement test 3–Administration manual.* Wilmington, DE: Jastak Associates, Inc.