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Title: Bilingualism, assessment language, and the Montreal Cognitive Assessment in Mexican Americans

Running title: Bilinguals and Montreal Cognitive Assessment

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Key points:

- Balanced bilingualism is common in a predominantly non-immigrant Mexican American community.
- Balanced bilinguals are more likely to choose English than Spanish for their cognitive assessment language.
- Balanced bilinguals that selected English for cognitive assessment performed better than balanced bilinguals that selected Spanish or both languages.

Why does this paper matter?

We demonstrate that bilingualism and assessment language selection are important to consider when investigating cognitive health in older Hispanic/Latinx adults in the US.

Abstract:

Background/Objectives: Assessment of cognition in linguistically diverse aging populations is a growing need. Bilingualism may complicate cognitive measurement precision, and bilingualism may vary across Hispanic/Latinx sub-populations. We examined the association among bilingualism, assessment language, and cognitive screening performance in a primarily non-immigrant Mexican American community.

Design: Prospective, community-based cohort study: The Brain Attack Surveillance in Corpus Christi (BASIC)-Cognitive study

Setting: Nueces County, Texas

Participants: Community-dwelling Mexican Americans age 65+, recruited door-to-door using a two-stage area probability sampling procedure.

Measurements: Montreal Cognitive Assessment (MoCA); self-reported bilingualism scale. Participants were classified as monolingual, Spanish dominant bilingual, English dominant bilingual, or balanced bilingual based upon bilingualism scale responses. Linear regressions examined relationships amongst bilingualism, demographics, cognitive assessment language, and MoCA scores.

Results: The analytic sample included 547 Mexican American participants (60% female). Fifty-eight percent were classified as balanced bilingual, the majority (88.6%) of whom selected assessment in English. Balanced bilinguals that completed the MoCA in English performed better than balanced bilinguals that completed the MoCA in Spanish ($b$ = -4.0, $p$ < .05). Among balanced bilinguals that took the MoCA in Spanish, education outside of the US was associated with better performance ($b$ = 4.4, $p$ < .001). Adjusting for demographics and education, we found no association between degree of bilingualism and MoCA performance ($p$’s >.10).

Conclusion: Bilingualism is important to consider in cognitive aging studies in linguistically diverse communities. Future research should examine whether cognitive test language selection affects cognitive measurement precision in balanced bilinguals.

Key words: Cognition, Bilingualism, Mexican American, Latinx, Hispanic

## Introduction

Adults of Hispanic/Latinx ethnicity are a rapidly growing segment of the aging population with considerable demographic, cultural, and linguistic diversity[1]. Characterizing the cognitive status and risk for cognitive impairment in Hispanic/Latinx older adults is of critical importance given that they may be at greater risk for dementia compared to non-Hispanic white populations[2]. The impact of the demographic, cultural, and linguistic characteristics on the cognitive assessment process is understudied.

Bilingualism is common among Hispanic/Latinx adults living in the US. According to a 2013 Pew Research Center National Survey of Latinos[3], 40% of Hispanics aged 65 and older are bilingual, whereas 47% mainly use Spanish and 13% mainly use English, with variability across Hispanic subgroups and by factors such as immigration status. Bilingualism is rarely reported in studies of mild cognitive impairment in Hispanics/Latinx adults in the US[4]. Bilingualism has been shown to be relevant in interpretation of cognitive performance in older adults, with inconsistent evidence for an association with reduced risk of cognitive impairment in older adults[5,6]. There is a dearth of information regarding how bilingualism impacts the selection of cognitive assessment language and whether this selection is associated with cognitive test performance.

In studies of mild cognitive impairment in Hispanics, selection of cognitive assessment language occurs overwhelmingly via individual preference[4]. It is unclear how bilinguals select their preferred cognitive assessment, whether this selection consistently aligns with language dominance and impacts cognitive test performance. Bilingual individuals faced with selecting their preferred testing language may do so without prior experience with cognitive assessment; as such, they may not have sufficient information regarding the linguistic demands of the cognitive assessment process to make a fully informed choice. Individuals with conversational fluency in a non-dominant language may have sufficient fluency to participate in an informal interview, yet not the higher-order fluency needed for complex cognitive processing in their non-dominant language, which is necessary for optimal performance on cognitive assessment[7,8]. This challenge is further complicated by the fact that many cognitive assessment tools have been under-validated in languages other than English[9]. Selection of assessment language may impact cognitive test performance in bilinguals, and complicates accurate assessment of cognitive functioning in these populations.

The objectives of this study were to: 1) describe the prevalence of self-reported bilingualism in a predominantly non-immigrant Mexican American older adult community; 2) examine the relationship between bilingualism and selection of cognitive assessment language; 3) examine demographic predictors of assessment language selection in balanced bilinguals; and 4) examine the relationships among test language, bilingualism, and performance on a cognitive screening instrument, the Montreal Cognitive Assessment (MoCA). We aimed to examine the association between test language and MoCA performance specifically within balanced bilinguals, in light of the challenges in selection of cognitive assessment language within this group. We hypothesized that: 1) bilingualism would be common in older Mexican Americans; 2) bilinguals with strong self-reported language dominance would consistently choose their dominant language for assessment, whereas assessment language selection would be less consistent for balanced bilinguals; and 3) greater degree of bilingualism (i.e., less language dominance) would be associated with higher cognitive performance.

## Methods

The BASIC-Cognitive study is a community-based study of cognition in older adults in Nueces County, Texas, USA, located on the Texas Gulf coast. Approximately 60% of Nueces County residents identify as Mexican American, the majority of whom are US citizens (96%) and US-born (92%)[10]. Detailed methodology for the BASIC-Cognitive project is available elsewhere[11]. Briefly, participants aged ≥65 were recruited via two-stage area probability sampling and door-to-door recruitment to aim for equal balance of Mexican American and non-Hispanic white participants. Participants completed the MoCA in their homes (or, rarely, in a different preferred, private location) as a part of eligibility screening for the larger study. Study procedures were approved by the Institutional Review Board of the University of Michigan Medical School.

*Participants*: Community-dwelling adults aged ≥65 and residents of Nueces County, Texas were eligible for participation. This analysis included Mexican American participants with complete data on MoCA, demographics, and bilingualism. Data were collected from May 3, 2018 toJanuary 30, 2020.

*Self-rated bilingualism*: To assess bilingualism, participants were first asked if they ever used another language for speaking, reading, or writing (Question 1). If they responded affirmatively, participants then rated their proficiency in English and Spanish (4 items per language, including speaking, understanding, writing, and reading) on 7-point Likert-like scale, with 1 corresponding to “almost none” and 7 corresponding to “like native speaker”[8]. A language dominance index was calculated with the following formula: (mean of English proficiency items)/(mean of English proficiency items plus mean of Spanish proficiency items) ([8]; range 0-1; 0.5 indicates equal English-Spanish proficiency; 1 indicates monolingual English speaker). Language dominance index values were assigned as 0 (monolingual Spanish) or 1 (monolingual English) for those that answered “no” to question 1 (English or Spanish determined based on interview language). Bilingualism was classified as follows: participants were classified as monolingual for language dominance index scores of 0 (monolingual Spanish) and 1 (monolingual English); participants with values >0.4 and <0.6 were classified as balanced bilinguals; participants with values >0 and <0.4 were classified as bilingual-Spanish dominant, and values >0.6 and <1 were classified as bilingual- English dominant.

*Cognitive screening*: The MoCA version 7.1[12] was used. We used the Spanish translation of the MoCA that is available on the website (www.mocatest.org). Minor adaptations were made to the standardized Spanish instruction script by local, bilingual field staff to be appropriate for local Spanish, although test stimuli and scoring criteria were not modified. MoCA administration was offered in English or Spanish by bilingual staff who were trained in administration and scoring by a clinical neuropsychologist (EMB). Although participants selected their preferred language for the assessment, they were informed that they could provide responses in either language. Staff were permitted to provide test instructions in either language, according to participant preference and staff judgment of participant’s comprehension of instructions, regardless of initial test language selection. This procedure was implemented to optimize accessibility and accuracy of the assessment process, as recommended for neuropsychological assessment of bilingual individuals[13]. Interviews that were administered in both languages were coded as bilingual interviews. Test language selection was made according to participant preference, consistent with standard practice[4]. The script and procedure for facilitating selection of test language are available in supplemental material (Supplemental Methods; Supplemental Table S1). We did not assign an extra MoCA point for those with ≤ 12 years of education because we included years of education as a covariate (score range 0-30, higher score indicates better performance).

*Analysis*: To examine the relationship between bilingualism classification and selection of cognitive assessment language, we performed a chi-square analysis. To examine demographic predictors of cognitive assessment language in balanced bilinguals, we performed a multinomial logistic regression within balanced bilinguals, with age (centered; both linear and squared terms), sex, years of education (centered), country of education, and language dominance index as predictors of assessment language. To examine the relationships among test language, bilingualism and MoCA, we performed a series of regressions. Within balanced bilinguals, we performed sequential linear regressions with MoCA score as the outcome and test language (model 1) and test language plus demographics (Model 2) as predictors. We repeated Model 2 analyses with MoCA sub-scores to explore item-specific relationships. Given the small ranges of the language, naming, and abstraction subdomain scores, we ran these analyses as ordinal logistic regressions. Next, we performed linear regression analyses separately within those that took the MoCA in English and Spanish, with language dominance index (Model 1) and both language dominance index and demographics (Model 2) as predictors. We performed this analysis separately within those that took the MoCA in English and Spanish given the directional metric of the language dominance index and its inverse implications across test language.

## Results

*Sample characteristics*: 547 community-dwelling Mexican American participants were included. Table 1 displays demographic characteristics and test language selection for the full sample and balanced bilinguals.

*Prevalence of self-reported bilingualism*: Twenty percent (108 of 547) of the sample were classified as monolinguals (n = 40 monolingual English; n = 68 monolingual Spanish). Fifty-eight percent (n =316) were classified as balanced bilingual, 6% (n = 35) were classified as Spanish-dominant bilingual and 16% (n = 88) were classified as English-dominant bilingual. Supplemental Table S2 displays mean ratings for each item of the bilingualism questionnaire within the full sample and balanced bilingual sample. Mean ratings revealed generally high self-rated proficiency across English and Spanish.

*Bilingualism, demographics, and test language selection*: There was a strong association between language-dominant bilingualism and selection of assessment language (Figure 1; Supplemental Table S3). Nearly all English-dominant bilinguals took the MoCA in English (n = 86 of 88), and most Spanish dominant bilinguals took the MoCA in Spanish (n = 29 of 35). Contrary to our hypothesis, a large majority (89%; n = 280 of 316) of balanced bilinguals chose to complete the MoCA in English, with the remainder taking the MoCA in Spanish (6%; n = 19 of 316) or in both languages (5%; n = 17 of 316). Within the balanced bilingual group, having fewer years of education and having received education outside of the US were associated with greater likelihood of taking the MoCA in Spanish compared to English, after accounting for the language dominance index. Gender and age were not associated with selection of test language in balanced bilinguals (Table 2).

*Language of testing and MoCA performance in balanced bilinguals*: Within balanced bilinguals, taking the MoCA in English was associated with higher MoCA scores compared to taking the MoCA in Spanish or in both languages (Table 3). Considering test language alone (Model 1), participants that took the MoCA in Spanish obtained an average score of 4 points lower than participants that took the MoCA in English; participants that took the MoCA in both languages obtained an average of 6.1 points lower than participants that took the MoCA in English. This relationship was attenuated and remained significant only for the English compared to both languages comparison, after accounting for demographics (Model 2). Individuals that took the MoCA in both languages performed an average of 3.2 points lower than individuals that took the MoCA in English, holding other covariates at a constant value. Examining MoCA sub-domains, when accounting for demographics, balanced bilinguals that took the MoCA in English had better performance on the attention domain compared to balanced bilinguals that took the MoCA in Spanish or in both languages. English MoCA participants had higher scores in the language domain than participants that took the MoCA in both languages, but lower scores than those that took the MoCA in Spanish. There were no differences by test language for domains of visuospatial/executive, naming, abstraction, delayed recall, or orientation (Supplemental Table S4).

*Language dominance and MoCA performance*: Finally, we examined whether self-reported language dominance was associated with performance on the MOCA, after accounting for demographics, separately within those that took the MoCA in English and in Spanish. We excluded those that completed the MoCA in both languages due to small sample size (n = 18). Language dominance was not a significant predictor of MoCA performance, and this association remained non-significant after accounting for demographics (Table 4). Among those that took MoCA in English, higher educational attainment and younger age were associated with higher MoCA scores. Among participants that took the MoCA in Spanish, in addition to higher educational attainment, having received education outside of the US was associated with MoCA scores an average of 4.4 higher, holding other covariates at a constant value.

## Discussion

We found that balanced bilingualism was common in a predominantly non-immigrant Mexican American community, with more than half of our sample characterized as balanced bilinguals. Language-dominant bilinguals consistently chose their dominant language for cognitive assessment, whereas balanced bilinguals showed a strong tendency to select English for their assessment. Balanced bilinguals that chose English for their assessment performed better on the MoCA than balanced bilinguals that chose Spanish for their assessment, which was attenuated after accounting for demographics. Balanced bilinguals who were educated outside of the US were more likely to choose Spanish for their assessment. Having received education outside of the US was associated with better cognitive performance in balanced bilinguals that took the MoCA in Spanish, but not in English. Accounting for demographics and education, we found no relationship between degree of bilingualism and cognitive assessment performance.

### *Prevalence of bilingualism in older Mexican Americans*

More than half of our population-based sample of older Mexican Americans reported balanced language proficiency across English and Spanish. This reflects a higher rate of bilingualism than has been reported in national surveys. The Pew Research Center reported a 40% rate of bilingualism in Hispanics aged 65 or higher, with differences by nativity status (more monolingual Spanish speakers among foreign-born Latinx) and Hispanic origin (e.g., fewer monolingual Spanish speakers among Puerto Ricans)[3]. Bilingualism is thus influenced by many demographic and cultural factors, and rates and degree of bilingualism likely vary across Hispanic/Latinx communities. This variability in rates and degree of bilingualism may contribute to conflicting evidence across studies regarding whether and how bilingualism impacts cognition and its measurement. Together, our findings underscore the need for assessment and reporting of bilingualism in studies of cognitive aging in Hispanic/Latinx communities.

*Bilingualism, selection of assessment language, and performance on the MoCA*

Among balanced bilinguals, those with fewer years of education and education outside of the United States were more likely to select assessment in Spanish. It is not surprising that educational experiences impact selection of assessment language; this aligns with previous work suggesting that factors such as academic experience and acculturation are important considerations when selecting cognitive assessment language[7]. In our sample, the majority of balanced bilinguals received their education in the US, which likely contributed to the strong tendency to select assessment in English.

Balanced bilinguals that chose the English MoCA obtained higher scores than balanced bilinguals that chose the Spanish MoCA and those that completed the MoCA in both languages. After accounting for years of education, country of education, age, and sex, this association remained significant for those taking the MoCA in both languages, but was attenuated for those that chose the Spanish MoCA. There are many possible interpretations of this finding. It is possible that other, unmeasured differences between these groups were present that differentially contribute to life-course cognitive risk and impact late-life cognitive health[14]. It is also possible that this difference was related to test language selection, such that balanced bilinguals who are primarily non-immigrant, received education in the US, and are longstanding residents in the US perform best on cognitive assessment in English. Finally, it should be noted that there have been limited studies focused on validation of the MoCA in Spanish speakers within the US, and no studies to date have confirmed the psychometric equivalence (i.e., measurement non-invariance) of the MoCA across English and Spanish. Analysis of MoCA sub-scores indicated that the attention domain was associated with better performance in English, whereas the language domain was associated with better performance in Spanish and worse performance for both languages compared to English. Differential difficulty across language is a concern and has been demonstrated in several cognitive instruments (e.g., [15–17]). Differential difficulty of the MoCA across language would have important implications for interpretation of cognition outcomes using the MoCA across English and Spanish speakers. The MoCA and its component sub-scores may be less predictive of consensus diagnosis of dementia in Latinx older adults as compared to non-Hispanic whites, and use of cut-scores validated in non-Hispanic white populations may over-classify impairment in Latinx populations[18,19]. Future work is needed to confirm psychometric equivalence of the MoCA across English and Spanish.

Previous work has been inconclusive regarding the association between assessment language and cognitive test performance in Hispanic/Latinx populations. For example, one study[20] found that Latinx adults that completed cognitive assessment with the Modified Mini Mental State Examination (3MSE) in English performed more poorly than Latinx adults that completed this assessment in Spanish. Another[15] found differences in performance in several cognitive tests across demographically-matched Latinx adults evaluated in English and Spanish. Other studies [21,22] have found minimal or no association between test language and performance. Variability in these findings may be related to factors such as sample characteristics (e.g., variability with regard to immigration status, degree of language dominance, and acculturation), analytic approach, and variability in domain and psychometric properties of cognitive assessment instruments.

We found differences in demographic predictors of performance across those that completed the MoCA in English and Spanish. Among those that took the MoCA in Spanish, education outside of the US was associated with higher MoCA scores. This association may reflect differences in cognitive health across these groups, as previous work[23] has found relatively greater risk for cognitive impairment within US-born Latinos compared to immigrant Latinos. Another possibility is that cognitive performance is optimized when assessment is performed in the language in which one received their education. Previous work has suggested that acculturation is an important consideration when selecting assessment language for balanced bilinguals[7]. This hypothesis warrants further exploration. Regardless of the possible causal explanations of this association, our finding that education country was associated with cognitive test performance within Spanish test takers underscores the importance of collecting and reporting this information in studies of cognitive aging of Latinx populations, whichis often unreported[4].

*Bilingualism and cognitive test performance*

We did not find an association between bilingualism and performance on the MoCA. These findings add to the conflicting body of evidence regarding whether and how bilingualism impacts cognition and whether it is protective with regard to cognitive impairment in older adults. Several cross-sectional studies have found that bilinguals outperform monolinguals on cognitive assessment in cross-sectional comparisons[5,22], whereas other studies have not found an association[24]. These studies vary with regard to many factors, including how bilingualism is defined and assessed, sample characteristics (e.g., immigration status, education, SES, Hispanic subpopulation), and analytic approach. Studies also vary with regard to the cognitive instruments used and domains assessed. The MoCA is a relatively brief cognitive screening instrument, and may not be sensitive to detect possible subtle cognitive advantages in language and executive functioning, which may be more reliably associated with bilingual advantages when these relationships are observed[25].

*Implications and future directions*

Our findings are expected to inform future studies investigating cognitive aging in Mexican American and other Latinx populations. First, our findings underscore the importance of measuring bilingualism in cognitive studies that include Latinx populations, and that bilingual staff are critical to ensure optimization of cognitive test performance in linguistically diverse populations. Our finding that balanced bilinguals who were educated in Spanish are likely to request cognitive assessment in Spanish may help with planning of bilingual staffing for future studies. Future studies should further examine factors contributing to selection of test language, and whether objective indicators should be used to inform selection of test language. Studies are needed that directly compare cognitive assessments completed across languages in balanced bilinguals. Demonstration of the psychometric equivalence of cognitive tests, including the MoCA, across languages, is urgently needed. Finally, future work is needed to examine how bilingualism is impacted by neurodegenerative processes and other neurologic conditions that are common in aging (e.g., stroke).

Our work has clinical implications. Consistent with recommendations,[13,26] our work supports the need to consider bilingualism when selecting a cognitive assessment approach with linguistically diverse older adults. Allowing access to both languages when performing cognitive assessments of bilinguals may optimize precision in the cognitive assessment process[13,27]. Our work also highlights the critical and growing need for bilingual clinical neuropsychologists and psychometrists who can perform culturally-sensitive bilingual neuropsychological assessments[28].

*Strengths and Limitations*: A strength of our study is our examination of bilingualism, cognitive assessment language, and performance in a Latinx community that is relatively culturally homogenous, which reduces concerns regarding unmeasured cultural differences within and across comparison groups. In terms of limitations, we used a brief, self-reported measure of bilingualism with a low time burden and did not measure other aspects of bilingualism that may be relevant (e.g., age of second language acquisition; frequency of use of each language). Although self-reported bilingualism tends to align well with objective indicators of bilingualism[5], we did not include an objective assessment of bilingualism. We are collecting these data on a subset of our participants and plan these analyses in future work. We did not use an aggregate measure of acculturation given evidence for its multidimensional relationship with cognition in Latinx populations[29,30] and aspects of acculturation may differentially vary across Latinx communities. We did not collect other relevant cultural characteristics such as generational status or number of years in the US, although we are collecting more comprehensive sociocultural information for participants that enroll in our longitudinal cohort. This was a population-based study; we did not exclude individuals or perform comprehensive medical assessment for diagnoses of dementia or other neurologic conditions. As a result, our sample reflects a broadly representative sample of the older Mexican American community. We did not randomly assign balanced bilinguals into test language condition, which would be necessary for causal inference regarding the association between test language and cognitive screening performance. We did not examine individual interviewer effects, although interviewers were consistently trained in study procedures.

*Conclusions*: Bilingualism is common in older, predominantly non-immigrant Mexican Americans and test language selection is associated with cognitive test performance in balanced bilinguals. Bilingualism is critical to assess when investigating cognitive health in Hispanic/Latinx populations in the US. Future work is needed to confirm psychometric equivalence of cognitive screening tests in English and Spanish and to determine how to optimize precision in measurement of cognitive health in the context of linguistic diversity.

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Author contributions:

Study concept and design: Briceño, Garcia, Gonzales, Heeringa, Levine, Langa, Longoria, Mehdipaneh, Morgenstern

Acquisition of subjects and/or data: Garcia, Longoria

Analysis and interpretation of data: Briceño, Heeringa, Zahs, Morgenstern

Preparation of manuscript: Briceño, Heeringa, Zahs, Morgenstern

Sponsor's role: None

Supplemental material: The supplemental material contains supplemental methods and 4 supplemental tables.

Supplemental methods:

Supplemental Table S1. Test language selection for bilinguals before and after procedure change

Supplemental Table S2. Bilingualism questionnaire. Mean rating score and standard deviation by language proficiency item

Supplemental Table S3. Test language choice by bilingualism classification

Supplemental Table S4: Regression coefficients for MoCA sub-scores on test language and demographics in balanced bilinguals (n=316)

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Table 1. Demographic characteristics of the sample

| Variable | Full sample (n = 547) | Balanced bilinguals (n = 316) | English-dominant bilinguals (n = 88) | Spanish-dominant bilinguals (n = 35) | Monolingual English (n = 40) | Monolingual Spanish (n = 68) |
|---|---|---|---|---|---|---|
| Age, years (Mean, SD) | 73.8 (6.9) | 73.8 (6.6) | 69.8 (4.5) | 78.5 (9.0) | 74.9 (6.9) | 76.3 (7.0) |
| Age, years (range) | 65-100 | 65-97 | 65-85 | 65-100 | 65-89 | 65-93 |
| Sex (n female, % female) | 328 (60.0%) | 201 (63.6%) | 45 (51.1%) | 24 (68.6%) | 16 (40.0%) | 42 (61.8%) |
| Years of education (Mean, SD) | 10.6 (4.5) | 11.4 (4.0) | 12.9 (2.9) | 6.8 (4.3) | 11.1 (3.9) | 5.5 (4.1) |
| Years of education (range) | 0-18 | 0-18 | 7-18 | 0-17 | 2-18 | 0-18 |
| Country of education (n, % USA) | 463 (84.6%) | 302 (95.6%) | 88 (100%) | 17 (48.6%) | 39 (97.5%) | 51 (75.0%) |
| Language dominance index (Mean, SD)[a] | 0.5 (0.24) | 0.5 (0.05) | 0.7 (0.0) | 0.3 (0.1) | 1 (0) | 0 (0) |

| | | | | | | |
|---|---|---|---|---|---|---|
| MoCA test language | | | | | | |
| English (n, %) | 412 (75%) | 280 (88.6%) | 86 (97.7%) | 6 (17.1%) | 40 (100%) | 0 (0%) |
| Spanish (n, %) | 117 (21.4%) | 19 (6.0%) | 1 (1.1%) | 29 (82.9%) | 0 (0%) | 68 (0%) |
| Both Spanish and English (n, %) | 18 (3.3%) | 17 (5.4%) | 1 (1.1%) | 0 (0%) | 0 (0%) | 0 (0%) |

*Note.* SD = standard deviation. MoCA = Montreal Cognitive Assessment. [a]Language dominance index possible range 0 (monolingual Spanish) to 1 (monolingual English).

Table 2. Multinomial logistic regression analysis for choice of Spanish or Both English and Spanish as the MoCA test language for balanced bilinguals (n = 316)

| Variable | Spanish language for cognitive testing[a] Odds ratio (95% CI) | Both English and Spanish languages for cognitive testing[a] Odds ratio (95% CI) |
|---|---|---|
| Education years, per one year increase | 0.7 (0.6, 0.9)** | 0.7 (0.6, 0.8)*** |
| Education country (outside of US)[b] | 16.2 (2.6, 99.0)* | 6.4 (0.9, 44.3)^ |
| Language dominance index (per 1 standard deviation increase)[c] | 0.52 (0.26, 1.03)^ | 0.39 (0.21, 0.72)* |
| Age (centered), per one year increase | 1.0 (1.0, 1.2) | 1.0 (0.9, 1.1) |
| Age (centered; squared) per one year increase | 1.0 (1.0, 1.0) | 1.0 (1.0, 1.0) |
| Sex (male)[d] | 1.5 (0.5, 4.5) | 1.2 (0.4, 4.0) |

*Note*. MoCA is Montreal Cognitive Assessment. [a]Reference category is English language MoCA. [b]Reference category is education in the US. [c]Language dominance index possible range 0 (monolingual Spanish) to 1 (monolingual English). [d]Reference category is female. ***$p$ < .001; **$p$ < .01; *$p$ < .05; ^$p$ < .10

Table 3. Coefficients and 95% confidence intervals for linear regression of MoCA score on demographics and test language for balanced bilinguals (n=316)

| Variable | Model 1 Coefficient (95% CI) | Model 2 Coefficient (95% CI) |
|---|---|---|
| Intercept | 19.9 (19.2, 20.5)*** | 19.5 (18.7, 20.3)*** |
| Test language (Both)[a] | -6.1 (-8.2, -4.0)*** | -3.2 (-5.6, -0.7)* |
| Test language (Spanish)[a] | -4.0 (-7.1, -1.0)* | -1.5 (-4.7,1.7) |
| Education, years (centered) | | 0.6 (0.4,0.7)*** |
| Country of education (other)[b] | | 1.1 (-1.7,3.9) |
| Age, years (centered) | | -0.2 (-0.3, -0.2)*** |
| Age, years (centered, squared) | | -0.0 (0.0, 0.0)^ |
| Gender (male)[c] | | -0.6 (-1.7, 0.5) |
| $R^2$ | 0.08*** | 0.33*** |

*Note*. [a]English test language is reference category. [b]USA is reference category. [c]Female is reference category. “Both” refers to taking the MoCA in both languages. ***$p$ <. 001; **$p$ < .01; *$p$ < .05; ^$p$ < .10. Age and education are centered at mean values. The intercept displays the average MoCA score for individuals in the reference category (i.e., females, tested in English, education in the US, mean age and years of education). Regression coefficients reflect the change in MoCA score points per unit increase in the covariate. $R^2$ values indicate the proportion of variance in MoCA scores explained by the variables in the model.

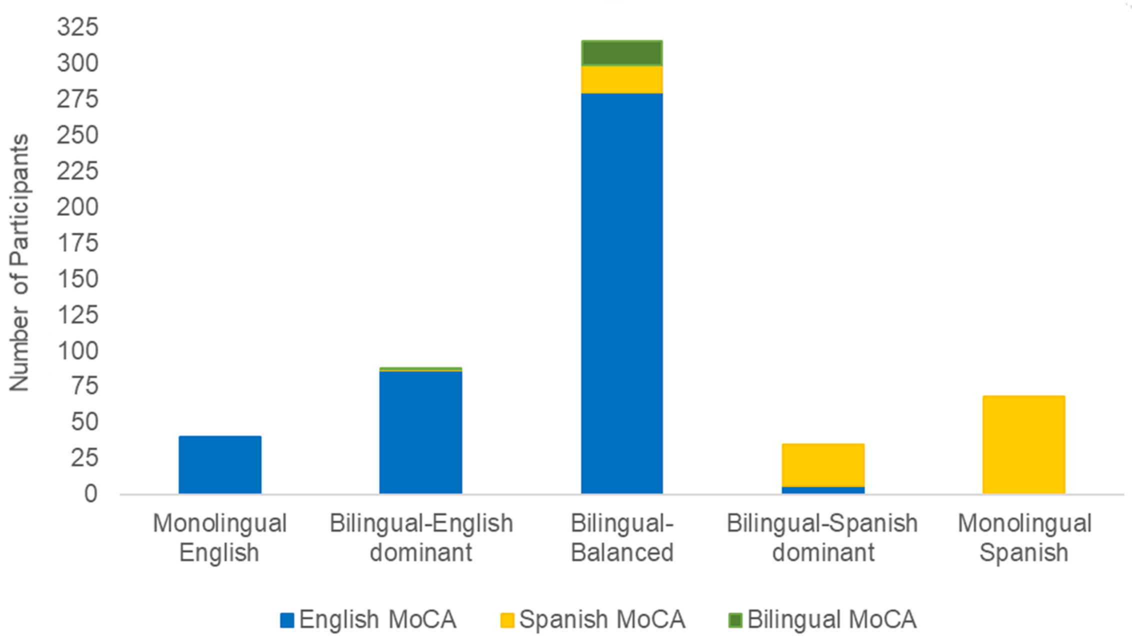
Table 4. Coefficients for linear regression of MOCA performance score on Language dominance index (LDI) and demographics by chosen test language

| | English language for cognitive testing (n = 412) | | Spanish language for cognitive testing (n = 117) | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 1 | Model 2 |
| Intercept | 19.9 (17.4, 22.5)*** | 19.9 (17.9, 21.9)*** | 15.4 (14.0, 16.9)*** | 14.9 (11.5, 18.4)*** |
| Language dominance index[a] | -0.2 (-4.4,3.9) | -0.8 (-4.1, 2.5) | 1.3 (-4.6, 7.2) | 4.1 (-1.8, 10.1) |
| Education, years (centered) | | 0.7 (0.5,0.8)*** | | 0.4 (0.1, 0.7)** |
| Country of education (outside of US)[b] | | -0.3 (-4.1,3.6) | | 4.4 (1.8, 7.1)** |
| Age, years (centered) | | -0.2 (-0.3,0.2)*** | | -0.1 (-0.3, 0.0)^ |
| Age, years (centered, squared) | | -0.01 (-0.02,-0.004)** | | -0.007 (-0.02, 0.003) |
| Sex (male)[c] | | -0.9 (-1.8, 0.1)^ | | -0.7 (-2.8, 1.4) |
| $R^2$ | 0.00 | .34*** | 0.00 | .38*** |

*Note.* ****p* <. 001; ***p* < .01; **p* < .05; ^*p* < .10 [a]Language dominance index possible range 0 (monolingual Spanish) to 1 (monolingual English). [b]Reference category is education in US.

[c]Reference category is female. Age and education are centered at mean values. The intercept displays the average MoCA score for individuals in the reference category (i.e., females, education in the US, with mean levels of language dominance index, age, and years of education). Regression coefficients reflect the change in MoCA score points per unit increase in the covariate. $R^2$ values indicate the proportion of variance in MoCA scores explained by the variables in the model.

Figure Caption: Figure 1. Bilingualism classification and MoCA test language selection. The figure displays frequencies of test language selection for participants classified as monolingual English, Bilingual-English dominant, Bilingual-Balanced, Bilingual-Spanish dominant, and monolingual Spanish.

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