Title

The state of neuropsychological test norms for Spanish-speaking adults in the United States

Journal

The Clinical Neuropsychologist, 35(2)

ISSN

1385-4046

Authors

Paredes, Alejandra Morlett
Gooding, Amanda
Fortuny, Lidia Artiola I
et al.

Publication Date

2021-02-17

DOI

10.1080/13854046.2020.1729866

HHS Public Access

Author manuscript

Clin Neuropsychol. Author manuscript; available in PMC 2022 February 01.

Published in final edited form as:

Clin Neuropsychol. 2021 February ; 35(2): 236–252. doi:10.1080/13854046.2020.1729866.

The State of Neuropsychological Test Norms for Spanish-Speaking Adults in the United States

Alejandra Morlett Paredes[a], **Amanda Gooding**[a], **Lidia Artiola i Fortuny**[b], **Monica Rivera Mindt**[c,d], **Paola Suárez**[e], **Travis M. Scott**[c,f], **Anne Heaton**[a], **Robert K. Heaton**[a], **Mariana Cherner**[a], **María J. Marquine**[a]

[a]Department of Psychiatry, University of California San Diego, United States;

[b]Private Practice, Tucson, Arizona;

[c]Department of Psychology and Latin American and Latina/o Studies Institute, Fordham University, New York, New York;

[d]Department of Neurology, The Icahn School of Medicine at Mount Sinai, New York, New York;

[e]Department of Psychiatry and Biobehavioral Sciences, University of California, Los Angeles;

[f]VA Palo Alto Health Care System, Sierra Pacific MIRECC

Abstract

Objective: The present review paper aimed to identify published neuropsychological test norms developed for Spanish-speakers living in the United States (U.S.).

Methods: We conducted a systematic review of the literature via an electronic search on PubMed using keywords “Normative data,” “Neuropsychological test,” “norms”, “Hispanic/Latinos,” “Spanish Speakers,” and “United States.” We added other studies and published manuals as identified by citations in papers from the original search.

Results: Eighteen sources of normative data for Spanish-speakers in the U.S. were identified. Of the 18 citations identified, only four provide normative data on comprehensive batteries of tests for Spanish-Speakers. Two of these are based on persons living in the southwest of the U.S., who tend to be of Mexican origin. Overall, a number of the studies are focused on older persons and although the majority include participants with wide ranges of education, participants in the ends of the education distribution tend to be underrepresented.

Conclusion: Here we provide a detailed description of the neuropsychological normative data currently available for Spanish-speakers living in the U.S. While there has been increased attention towards developing norms for neuropsychological batteries in Spanish-speaking countries (e.g. Latin America and Spain), there is still an urgent need to standardize neuropsychological tests among diverse groups of Spanish-speaking adults living in the U.S. The present review presents a list of norms for U.S.-dwelling Spanish-speakers, thus providing an important tool for clinicians and researchers.

Corresponding Author: María J. Marquine, PhD, 9500 Gilman Dr. #0664, La Jolla, CA 92093, Phone: 858-534-6748, Fax: 858-534-5475, mmarquine@ucsd.edu.

Keywords

Neuropsychological tests; Spanish-speakers; Hispanic/Latino; Norms

Introduction

Hispanics/Latinos/as are the largest ethnic minority group in the United States (U.S.; 18.1%). They are also one of the fastest growing populations in the nation, with a projected increase from 58.9 million in 2017 to 119 million by 2060 (Census Bureau, 2018a). The term “Hispanic or Latino,” as defined by the U.S. Office of Management and Budget (Census Bureau, 2018b), refers to persons of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race. We acknowledge that there are different terms used to refer to this heterogenous group, including Hispanic, Latino/a or Latinx (a gender-neutral/non-binary term to identify a person of Latin American origin or descent; Merriam-Webster, 2018), and for simplicity we will use the term Latino in this paper.

While there are salient cultural aspects that characterize the Latino collective experience, there is great diversity within Latino populations. They comprise multiple national origins, sociopolitical and economic statuses, racial groups, immigration statuses, acculturation patterns, educational backgrounds and language uses (Guarnaccia et al., 2007; Llorente, 2008; Pontón & Ardila, 1999; Rivera Mindt et al., 2008; Rivera Mindt, Byrd, Saez, & Manly, 2010; Salinas, 2016). Most Latinos in the U.S. are of Mexican origin/descent (63% of the total Latino population), followed by 9% Puerto Ricans and 4% Cubans (Census Bureau, 2017). Predominantly, Latinos (particularly those of Mexican origin) live in the West and South of the U.S. with Texas, California, New Mexico, Arizona and Nevada being the states with the largest Latino concentrations (Stavans, 2018). However, an ample number of Latinos also reside in the East side of the U.S., such as New Jersey, New York, and Florida, where most Latinos are of Caribbean descent (Census Bureau, 2017). Among Latinos living in the U.S over the age of 5 years, 72.4% speak Spanish at home (Census Bureau, 2017). Among those who speak Spanish, 57.5% also report speaking English “very well.” This number suggests a large proportion of Spanish-speakers in the U.S. are bilingual with potentially different levels of proficiency in both their native Spanish and English languages.

Despite the large number of Spanish-speakers in the U.S., there is a paucity of available neuropsychological test normative data for this population. It is well understood that simply translating cognitive tests from English to Spanish does not adequately consider important cultural, linguistic, and demographic factors that impact test performance (Ardila, Rodriguez-Menéndez, & Rosselli, 2002; Arnold, Montgomery, Castañeda, & Longoria, 1994; Brickman, Cabo, & Manly, 2006; Buré-Reyes et al., 2013; Díaz-Venegas, Downer, Langa, & Wong, 2016; Gasquoine, 2001; Heaton, Ryan, & Grant, 2009; Puente & Ardila, 2000). The application of normative data based on samples that closely resemble some of the main characteristics of the population assessed is of great importance for accurate diagnoses of (both acquired and developmental) neurocognitive impairment. Most

neuropsychological tests have historically been developed and standardized in a subsample of the world population, mostly with individuals from well-educated majority populations within contemporary Western, industrialized, wealthy, and democratic backgrounds (Henrich, Heine, & Norenzayan, 2010). Thus, what we know about cognition and its disorders within other countries and cultures is not only limited but, unquestionably, culturally biased (Ardila, 1996; Fletcher-Janzen, 2000; Uzzell, Pontón, & Ardila, 2013).

A number of studies highlight how the mismatch between the normative group and the population being evaluated can affect diagnostic accuracy in cognitive disorders. In one recent study, application of North American norms to groups from Morocco, Spain and Colombia resulted in misdiagnosis of impairment up to 20% of the time (Daugherty, Puente, Fasfous, Hidalgo-Ruzzante, & Pérez-Garcia, 2017). Cherner and colleagues (2007) demonstrated elevated rates of neurocognitive impairment on memory tests in a sample of healthy U.S.-dwelling Spanish-speakers when using published norms for non-Latino English-speakers compared population-specific norms. Misdiagnosis was particularly salient among participants with less than six years of education (Cherner et al., 2007) but was observed across the education range. Similarly, Casaletto et al. (2016) found high rates of neurocognitive impairment (27–31%) on the National Institutes of Health Toolbox Cognition Battery (NIHTB-CB) among healthy adult Spanish-speakers when applying demographically-adjusted norms that were developed with non-Latino English-speakers. Together, this literature strongly suggests that population-specific norms yield more accurate determinations of neurocognitive impairment, pointing to the importance of applying norms established on samples that resemble the population being assessed (Rivera Mindt et al., 2019; Rivera Mindt et al., 2010).

A recent survey (Rabin, Paolillo, & Barr, 2016) polling U.S. and Canadian members of the International Neuropsychological Society (INS) and the National Academy of Neuropsychology (NAN) identified some of the most frequently used neuropsychological assessment instruments. The majority of these instruments lack appropriate normative data for Spanish-speaking populations in the U.S. Furthermore, some of the most frequently reported challenges associated with selection of testing instruments included a “lack of adequate normative data” (33.5% of survey respondents) and that “tests are culturally biased” (11.5%). Relatedly, 15.9% of respondents rated “lack of norms for additional demographic groups” as a challenge to data interpretation (Rabin et al., 2016).

For those instruments where norms for Spanish-speaking adults are not available, clinicians in the U.S. are forced to either rely on existing non- Latino norms for data interpretation, use norms collected in other Spanish-speaking countries, such as México and Spain, develop personalized estimates through clinical experience (i.e., “clinical judgment”), and/or use raw scores for interpretation without a normative comparison. Although not meant to be a comprehensive list, examples of test batteries that were standardized and normed in other Spanish-speaking countries include the *Batería Woodcock-Muñoz* which included samples from urbanized areas in Costa Rica, México, Peru, Puerto Rico and Spain (Muñoz-Sandoval, Woodcock, McGrew, Mather, & Ardoino, 2009); the Spanish Multicenter Normative Studies in Spain (Neuronorma Project; (Peña-Casanova et al., 2009), the *NEUROPSI* in México (Ostrosky-Solis, Ardila, & Rosselli, 1999), the Boston Diagnostic Aphasia Exam (BDAE)

norms from Rosselli and colleagues in Colombia (Rosselli, Ardila, Florez, & Castro, 1990) and the norms from 11 Latin American countries presented by Arango-Lasprilla and colleagues (Guàrdia-Olmos, Peró-Cebollero, Rivera, & Arango-Lasprilla, 2015). For an overview of additional instruments and norms for other underrepresented minority populations, such as African American (AA) and Asian/Asian-American (Asian) populations, please see Rivera Mindt et al. (2019). All of these resources could be useful for those working with culturally/ linguistically diverse older adults.

Norms developed for Spanish-speakers in countries other than the U.S. undoubtedly have been a valuable resource for clinicians and researchers in the U.S. and abroad, though to our knowledge this is the first publication providing a comprehensive list of such resources. The main purpose of the present review was to identify norms that have been developed specifically for Spanish-speaking adults living in the U.S., and to describe the sample characteristics and test batteries for easy reference.

Methods

In an effort to compile a comprehensive list of available norms, we employed a systematic review of the literature to identify published norms that were developed for Spanish-speakers in the U.S. We conducted an electronic search on PubMed, using keywords “Normative data,” “Neuropsychological test,” “norms”, “Hispanics/Latinos,” “Spanish-Speakers”, and “United States.” This effort resulted in 59 citations from which relevant studies were selected for review. From that sample, 18 citations were identified as sources of normative data for Spanish-speaking adults living in the U.S. In addition, we added a battery that provides normative data in a sample of Spanish-speakers living in the U.S-Mexico border region, which is published in a manual (Artiola i Fortuny, 1999) resulting in a total of 19 studies for inclusion in this study.

Results

Table 1 provides a summary of the normative studies among Spanish-speakers in the U.S (including both comprehensive test batteries and single tests). A number of these studies consisted of co-normed batteries of neuropsychological tests (Artiola i Fortuny, 1999; Casaletto et al., 2016; Hall et al., 2018; LaRue, Romero, Ortiz, Chi Lang, & Lindeman, 1999; O’Bryant et al., 2018; Pontón et al., 1996; Stricks, Pittman, Jacobs, Sano, & Stern, 1998) as opposed to single-test norms (Acevedo et al., 2000; Cherner et al., 2007; González, Mungas, & Haan, 2005; González, Mungas, Reed, Marshall, & Haan, 2001; Jacobs, Winston, & Polanco, 1997; Marquez de la Plata et al., 2009; Marshall, Mungas, Weldon, Reed, & Haan, 1997; Menon, Hall, Hobson, Johnson, & O’bryant, 2012; Strutt et al., 2012; Strutt, Scott, Shrestha, & York, 2011). Below is a description of each battery (7 in total) that has available norms for Spanish-speaking adults in the U.S. Information on the single-test norms (11 in total) are available in Table 1, but will not be explained in the text below.

Pontón and colleagues (1996) provided normative data on the Neuropsychological Screening Battery for Hispanics (NeSBHis), which measures a range of domains, including attention/ concentration, psychomotor speed, nonverbal reasoning, visuospatial functions, language,

and learning and memory (see Table 1 for specific tests). The sample consisted of 342 participants from different community centers of the greater Los Angeles area, with wide ranges of ages (16–75 years) and education (1–20 years). Sixty-two percent of the participants identified Mexico as their country of origin, 15% came from Central America, and 23% came from other countries. Importantly, this study collected information on the average duration of residence in the U.S. and country of origin, which are variables sometimes not reported by other studies. The majority had lived at least 15 years in the U.S. (55%), and 45% of the subjects had less than six years of residence in this country. Participants were mostly monolingual Spanish-speaking (70%), with 30% being bilingual. Besides reporting the typical main effects of age, education, and gender, significant interaction effects between demographic factors on a number of neuropsychological tests were investigated (e.g. age X education X gender, and age X education). Means and SDs are reported by gender, age (16–19, 30–39, 40–49, and 50–75) and years of education (+/− 10 years).

Stricks and colleagues (1998) provide normative data on a neuropsychological battery assessing cognitive functions typically affected in dementia such as orientation, learning and memory, attention, verbal and non verbal reasoning, and visoperceptual skills (see Table 1 for specific tests) in 416 older (60+ years) Spanish-speakers, who were part of a larger community-based, epidemiologic study of dementia in the New York City area. The majority of Spanish-speakers in this study were of Caribbean origin (i.e., Dominican Republic, Puerto Rico, and Cuba). This study investigated both univariable effects of demographics (i.e., age, education, and gender), and their interaction on test performance. Norms for Spanish-speakers were stratified by two education groups (less than 9 years and 9 years or more) and three age ranges (60–69, 70–70 and 80+).

Artiola I Fortuny (1999) developed the *The Batería Neuropsicológica en Español*, which includes eight neuropsychological tests assessing attention, language, executive functions, and verbal and visual learning and memory (see Table 1 for a list of specific tests). The sample consisted of 185 Spanish-speakers from the U.S./México border region and 205 from Spain. Of relevance for purposes of the present review, the border region sample included participants ages 18 to 65+ and with 0 to 16+ years of education (75% female). Participants were recruited from a predominantly suburban population, and the sample consisted of individuals who lived in the U.S., Mexico, or both countries. They were primarily individuals of Mexican origin who had immigrated to the U.S. or resided in the towns of Nogales or Agua Prieta, Sonora, and had a high degree of familiarity with the culture and society of the U.S. Norms are provided separately for the two samples, stratified by spans of age (18–34, 35–44, 45–54, 55–64, >65) and years of education (0–2, 3–5, 6–8, 9–11, 12, 13–15, <16).

LaRue and colleagues (1999) provided preliminary normative tables for a battery of neuropsychological tests measuring attention, immediate and secondary memory, learning, psychomotor speed and cognitive flexibility in a sample of older adults (Latino and non-Latino) from New Mexico. The majority of Latino participants (90%) were born in the U.S. and identified themselves as Spanish American (83%), with 10% describing themselves as Mexican-American, and 5% as Latino/Native American. Of the 359 Latino participants

included in the study, 79% elected to complete the cognitive tests in English,14% in Spanish, and 7% in a combination of English and Spanish. Significant predictor variables included in this study were ethnicity, sex, education, age, depression (GDS total score), and health (number of self-reported medical illnesses) on almost every neuropsychological test. La Rue provides preliminary normative tables for Latino older adults stratified by age (65–74 years and 75–97 years) and education (0–6years, 7–9 years, 10–12 years, and > 12 years).

Casaletto and colleagues (2016) developed norms for the Spanish version of the National Institites of Health Tool Box-Cognitive Battery (NIHTB-CB; Casaletto et al., 2016). This 30-min computerized battery includes seven measures and assesses six neurocognitive domains (i.e., Attention, Executive Functions, Episodic Memory, Processing Speed, Working Memory, and Language; see Table 1). The NIHTB-CB Toolbox normative Spanish-speaking sample of adults consisted of 408 neurologically healthy adults (ages 18–85 years; 65% female) from Atlanta, Chicago–Oak Brook, Cincinnati, Columbus, Dallas, Los Angeles, Minneapolis, Philadelphia, Phoenix, and Saint Louis. The majority of participants who completed the battery self-identified as Latino White (77%). The sample included individuals with fairly heterogenous levels of Spanish proficiency and bilingualism (participants were not objectively assessed for English versus Spanish language proficiencies). Casaletto and colleagues (2016) developed three types of scores in this battery for each of the seven NIHTB-CB tests and three composites (Fluid, Crystallized, Total Composites): normalized but uncorrected scaled scores, age-corrected scaled scores, and fully demographically corrected T-scores, which considered age, education and sex. The development of demographically-adjusted norms considered both linear and nonlinear effects of demographic factors.

Two studies have been published as part of the Texas Mexican American Adult Normative Study (TMAANS) initiative (Hall et al., 2018; O'Bryant et al., 2018), which include a number of tests covering visuospatial/constructional abilities, attention, language, executive functioning, and immediate and delayed memory domains. TMAANS includes data from Mexican American middle-aged and older adults recruited from three different cohorts (i.e. TARCC, HABLE, and Project FRONTIER). There is significant overlap on the neurocognitive test batteries across cohorts, but the batteries are not identical (see O'Briant et al. 2018 for details). The first TMAANS study (O'Bryant et al., 2018) included 797 Mexican-Americans aged 40+ from Texas (73.4% female, 52% Spanish-speaking). Data on memory tests were available from HABLE (n=387) and TARCC (n=266) cohorts, except data on the Rey Auditory Verbal Learning Test (RAVLT) were available from HABLE only. The study presented normative data for English and Spanish-speakers together, stratified by education (0–6, 3–9, 6–12 and 12+) and age (40–60 and 61+) for most tests in the battery (see Table 1 for a full list of tests), except for tests of word reading, which differed by language use (i.e. Word Accentuation Test for Spanish-speakers and the American National Reading Test for English-speakers). Multivariable linear regression models on each test were performed to examine the linear, main effects of age, education, gender and language on each test (i.e., interactions among these factors were not examined). Education and age were the two demographic factors that generally accounted for the greatest amount of variance in neuropsychological test scores. Language of administration was significant for the Trail Making Test-A, the Consortium to Establish a Registry for Alzheimer's Disease (CERAD)

List Learning and CERAD List Recall, but normative data were not provided separately for Spanish-speakers.

The second TMAANS project included 136 Latinos (67 primarily Spanish-speaking and 69 primarily English-speaking; for overall cohort: age= 40–79, Education= 0–18, 79% female) recruited as part of the Project FRONTIER from a rural population in the Texas – New Mexico border region (Hall et al., 2018), who had completed the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)- Form A. To avoid dilution of the sample size into smaller subgroups, stratification was conducted for demographic factors that accounted for 10% or more of the variance. For this reason, only education was included in normative corrections for most RBANS subtests (Education ranges: 0–6, 7–11, and 12+), with separate norms being provided by language only for the Digit Span subtest.

Table 1 provides further details about the above-mentioned seven studies. In addition, Table 1 includes information on single-test norms for U.S.-dwelling Spanish speakers.

Discussion

While considerable efforts have been undertaken over the past two decades to develop neuropsychological test normative data for Spanish speakers living in the U.S., these data are limited, particularly when compared to those available for English-speakers in the U.S. Of the 18 sources of normative data for Spanish-speaking adults in the U.S. that were identified, only four provide normative data separately for Spanish-speakers on batteries that assess multiple domains of cognitive functioning. Besides these four studies, an additional three studies provide norms for primarily English- and primarily Spanish-speaking Latinos together on a battery of tests (Hall et al., 2018; LaRue, Romero, Ortiz, Chi Lang, & Lindeman, 1999; O'Bryant et al., 2018). Co-norming of tests is important as it increases clinical utility of results and the applicability of norms (Kern et al., 2008; Rodriguez-Jimenez et al., 2012; Shi et al., 2015). Yet, findings from the present literature review indicate a relative paucity of co-normed batteries that allow for comparison of performance across multiple domains of cognitive functioning among Spanish-speakers in the U.S. Furthermore, while the existing batteries cover a variety of domains, they include normative data on a limited number of tests of executive function and visuo-spatial skills.

The majority of available batteries with norms specifically for Spanish-speakers are based on persons living in the southwest of the U.S., who tend to be of Mexican origin (Artiola i Fortuny, 1999; Pontón et al., 1996; Strutt et al., 2012). Only one of the studies including a co-normed battery was conducted in the northeast (Stricks et al., 1998), and only one included participants from various regions in the U.S. (Casaletto et al., 2016). This indicates a clear gap in the availability of norms for Latinos from Central and South America living in the U.S. Further, a number of these studies are focused only on older persons (LaRue et al., 1999; Stricks et al., 1998; Strutt et al., 2012), with others including broader – though limited – adult age ranges (Artiola i Fortuny, 1999; Casaletto et al., 2016; Pontón et al., 1996). In general, these studies include participants with wide ranges of education (1–20 years), though many note that representation of participants at the ends of the education distribution tends to be low. As such, current co-normed batteries for U.S. Spanish-speaking adults may

be particularly innapropiate for individuals with less than 6 or greater than 18 years of education. Even though there are two studies (Artiola et al.,1999 and Pontón et al.,1996) that include participants with less than one year of education, these samples are still small and collapsed together within the norms of those with 6 or less years of education. Relatedly, no norms have been specifically developed for Spanish-speakers living in the U.S. who are illiterate.

In addition to the limited availability of co-normed data, an important limitation that applies to nearly all normative studies among Spanish-speakers in the U.S. are the relatively small samples sizes, which may influence the robustness of the norms and limit power to investigate interactions among demographic variables (e.g. age X education X gender) on test performance. A number of the studies include both monolingual and bilingual Spanish speakers in their sample (Artiola i Fortuny, 1999; González et al., 2001; LaRue et al., 1999; Pontón et al., 1996; Stricks et al., 1998), which may indeed be representative of Latinos in the U.S., yet most do not report on the impact that bilingualism might have on neuropsychological tests performance. In recent years, there has been an increase in research investigating the effect of bilingualism on cognitive and linguistic processing (Bialystok, 2018; Lehtonen, Soveri, Laine, Järvenpää, de Bruin, & Antfolk, 2018). Yet, a significant barrier to research is the absence of proper assessment indicating the degree of bilingualism of each individual. A majority of the existing 18 sources of normative data found in this review, do not report on bilingualism (Acevedo et al., 2000; Casaletto et al., 2016; Cherner et al., 2007; Gonzalez et al., 2002; Hall et al., 2018, Marshall et al., 1997; Marquez et al., 2009; O'Bryant et al., 2018; Stricks et al., 1998; Strutt et al., 2012; Strutt et al., 2011) and those that do report on it rely entirely on self-report questionnaires to collect this information (Gonzalez et al., 2001; Jacobs et al., 1997; La Rue et al., 1999; Menon et al., 2012; Pontón et al., 1996).

Bilingualism is a complex experience that could be shaped by social, cultural, and contextual factors (Anderon, Mak, Chahi and Bialystok, 2018). Luk and colleagues (2013) described language experience as a continuum, meaning that Individuals are not categorically bilingual or monolingual. The ambiguity that surrounds bilingualism creates an important methodological issue in research studies specifically when trying to develop appropriate norms for bilinguals. Resolving this methodological problem of how to characterize participants on the multidimensional continuum of the bilingual experience could contribute to a theoretical discussion of the nature of language experience, and measurement issues of quantifying this experience. One relatively simple and feasible approach to quantify degree of English fluency among Spanish-speakers has been previously presented by Suarez and colleagues (2014), and is based on developing a ratio of words produced in verbal fluency tasks in Spanish and English. The incorporation of this type of measure and other structured instruments quantifying bilingualism into normative studies, will be important to identifying measureble and replicable ways to consider bilingualism in the development and application of norms.

Relatedly, few studies provide specific information on other culturally relevant variables, which might have important influences on test performance among Spanish-speakers in the U.S. Examples include degree of acculturation, country of birth/origin and country where

education was obtained, years of school completed in the U.S., or years of residence in the U.S. (Acevedo et al., 2000; Artiola i Fortuny, 1999; Cherner et al., 2007; Flores et al., 2017; Hall et al., 2018; O'Bryant et al., 2018). As noted above, most studies were conducted in the southwest of the U.S., which contains a primarily Mexican-American population (Artiola i Fortuny, 1999; González et al., 2005; González et al., 2001; Hall et al., 2018; LaRue et al., 1999; O'Bryant et al., 2018; Pontón et al., 1996) and thus norms resulting from these studies should be used with caution in other Spanish-Speaking Latino populations in the U.S. (i.e., persons from Caribbean, Central American, or South American origin; Stricks et al., 1998). Future studies with large numbers of well-characterized diverse groups of Spanish-speakers in the U.S., and which incorporate comprehensive cognitive batteries, would allow for the development of robust normative data that incorporate adjustment for important sources of neuropsychological performance variance in this population.

Conclusion

While there has been increased attention towards developing norms for neuropsychological batteries in Spanish-speaking adults in Latin America (e.g., Arango-Lasprilla, Stevens, Morlett Paredes, Ardila, & Rivera, 2017; Guàrdia-Olmos et al., 2015; Rosselli et al., 1990) and Spain (e.g. Peña-Casanova et al., 2009), there is still an urgent need to standardize neuropsychological tests among diverse groups of Spanish-speaking adults living in the U.S. Future norming efforts should gather detailed culturally-relevant information (e.g., acculturation, linguistic background/proficiency, bilingualism, country where education was completed, quality of education, number of years in the U.S., among others), and examine the effects of these variables on neuropsychological test performance. Results of such studies might help guide which variables ought to be considered in the development of norms for most accurately identifying underlying brain impairment in this population. In addition, the collection of this culturally-relevant information could better help researchers and clinicians identify which norms to use for their patients and research samples.

The present review paper provides a list of published norms for neuropsychological tests for Spanish-speaking adults living in the U.S. and is part of a special issue on this topic. The articles that follow in this special issue provide results from a series of studies from the Neuropsychological Norms for the U.S.-Mexico Border Region (NP-NUMBRS) project. As part of this issue, our group presents a series of normative studies on a comprehensive neuropsychological test battery for Spanish-speaking adults living in the U.S-Mexico border region (Diaz-Santos, 2020; Gooding et al., 2020; Heaton et al., 2020; Marquine et al., 2020a; Marquine et al., 2020b; Morlett Paredes et al., 2020; Rivera et al., 2020a; Scott et al., 2020; Suarez et al., 2020a), a study that investigates the impact of English language fluency in this comprehensive battery of tests (Suarez et al., 2020b), and a study that examines the utility of this battery in detecting HIV-associated neurocognitive impairment (Kamalyan et al, 2020). Based on the present literature review and findings from the NP-NUMBRS project presented in this special issue, we provide a more detailed set of recommendations (Rivera Mindt et al., 2020b) to help advance the field of neuropsychological assessment among Spanish-speakers in the U.S., and the clinical application of neuropsychological norms in this population.

Acknowledgments

This research was supported in part by grants from the National Institutes of Health (K23MH105297; P30AG059299, T32MH019934), the UCSD Hispanic Center of Excellence and the HIV Neurobehavioral Research Center (HNRC).

References

Acevedo A, Loewenstein DA, Barker WW, Harwood DG, Luis C, Bravo M, . . . Duara R (2000). Category fluency test: normative data for English-and Spanish-speaking elderly. Journal of the International Neuropsychological Society, 6(7), 760–769. [PubMed: 11105466]

Anderson JA, Mak L, Chahi AK, & Bialystok E. (2018). The language and social background questionnaire: Assessing degree of bilingualism in a diverse population. Behavior research methods, 50(1), 250–263. [PubMed: 28281208]

Arango-Lasprilla JC, Stevens L, Morlett Paredes A, Ardila A, & Rivera D. (2017). Profession of neuropsychology in Latin America. Applied Neuropsychology: Adult, 24(4), 318–330. [PubMed: 27282450]

Ardila A. (1996). Towards a cross-cultural neuropsychology. Journal of Social and Evolutionary Systems, 19(3), 237–248.

Ardila A, Rodriguez-Menéndez G, & Rosselli M. (2002). Current issues in neuropsychological assessment with Hispanics/Latinos. Minority and cross-cultural aspects of neuropsychological assessment, 161–179.

Arnold BR, Montgomery GT, Castañeda I, & Longoria R. (1994). Acculturation and performance of Hispanics on selected Halstead-Reitan neuropsychological tests. Assessment, 1(3), 239–248.

Artiola i Fortuny L. (1999). In Manual de Normas y Procedimientos Para La Bateria Neuropsicologia: Taylor & Francis.

Bialystok E. (2018). Bilingualism and executive function. Bilingual cognition and language: The state of the science across its subfields, 54, 283.

Brickman AM, Cabo R, & Manly JJ. (2006). Ethical issues in cross-cultural neuropsychology. Applied Neuropsychology, 13(2), 91–100. [PubMed: 17009882]

Buré-Reyes A, Hidalgo-Ruzzante N, Vilar-López R, Gontier J, Sánchez L, Pérez-García M, & Puente AE (2013). Neuropsychological test performance of Spanish speakers: Is performance different across different Spanish-speaking subgroups? Journal of Clinical and Experimental Neuropsychology, 35(4), 404–412. [PubMed: 23496164]

Casaletto KB, Umlauf A, Marquine M, Beaumont JL, Mungas D, Gershon R, . . . Heaton RK (2016). Demographically corrected normative standards for the Spanish language version of the NIH toolbox cognition battery. Journal of the International Neuropsychological Society, 22(3), 364–374. [PubMed: 26817924]

Census Bureau, U. (2017). Facts for Features: Hispanic Heritage Month 2017. Retrieved from https://www.census.gov/newsroom/facts-for-features/2017/hispanic-heritage.html.

Census Bureau, U. (2018a). Hispanic Heritage Month 2018. Washington D.C Retrieved from https://www.census.gov/newsroom/facts-for-features/2017/hispanic-heritage.html.

Census Bureau, U. (2018b). About Hispanic Origin. Retrieved from https://www.census.gov/topics/population/hispanic-origin/about.html.

Cherner M, Suarez P, Lazzaretto D, Fortuny i Artiola L, Mindt MR, Dawes S, . . . group, t. H. (2007). Demographically corrected norms for the Brief Visuospatial Memory Test-revised and Hopkins Verbal Learning Test-revised in monolingual Spanish speakers from the U.S.–Mexico border region. Archives of Clinical Neuropsychology, 22(3), 343–353. doi:10.1016/j.acn.2007.01.009 [PubMed: 17293078]

Daugherty JC, Puente AE, Fasfous AF, Hidalgo-Ruzzante N, & Pérez-Garcia M. (2017). Diagnostic mistakes of culturally diverse individuals when using North American neuropsychological tests. Applied Neuropsychology: Adult, 24(1), 16–22. [PubMed: 27485042]

Diaz-Santos M, Suarez P, Umlauf A, Marquine MJR, Mindt M, Artiola I Fortuny L, … Group, H. (2020). Updated demographically adjusted norms for the Brief Visuospatial Memory Test-Revised

and Hopkins Verbal Learning Test-Revised in Spanish speakers from the U.S.-Mexico border region: NP-NUMBRS project. The Clinical Neuropsychologist, 34, XX–XX.

Díaz-Venegas C, Downer B, Langa KM, & Wong R. (2016). Racial and ethnic differences in cognitive function among older adults in the USA. International journal of geriatric psychiatry, 31(9), 1004–1012. [PubMed: 26766788]

Fletcher-Janzen E, Strickland TL, & Reynolds C. (2000). Handbook of cross-cultural neuropsychology. New York: Springer Science & Business Media.

Flores I, Casaletto KB, Marquine MJ, Umlauf A, Moore DJ, Mungas D, . . . Heaton RK (2017). Performance of Hispanics and Non-Hispanic Whites on the NIH Toolbox Cognition Battery: The roles of ethnicity and language backgrounds. The Clinical Neuropsychologist, 31(4), 783–797. [PubMed: 28080261]

Gasquoine PG (2001). Research in clinical neuropsychology with Hispanic American participants: A review. The Clinical Neuropsychologist, 15(1), 2–12. [PubMed: 11778577]

Gooding A, Seider T, Marquine MJ, Suarez PA, Umlauf A, Rivera Mindt M, Heaton RK, Artiola I Fortuni L, & Cherner M. (2020). Demographically-Adjusted Norms for the Paced Auditory Serial Addition Task and Letter Number Sequencing Test in Spanish Speakers from the US-Mexico Border Region. The Clinical Neuropsychologist, 34, XX–XX.

González HM, Mungas D, & Haan MN (2005). A semantic verbal fluency test for English-and Spanish-speaking older Mexican-Americans. Archives of Clinical Neuropsychology, 20(2), 199–208. [PubMed: 15708730]

González HM, Mungas D, Reed BR, Marshall S, & Haan MN (2001). A new verbal learning and memory test for English-and Spanish-speaking older people. Journal of the International Neuropsychological Society, 7(5), 544–555. [PubMed: 11459106]

Guàrdia-Olmos J, Peró-Cebollero M, Rivera D, & Arango-Lasprilla JC (2015). Methodology for the development of normative data for ten Spanish-language neuropsychological tests in eleven Latin American countries. NeuroRehabilitation, 37(4), 493–499. [PubMed: 26577889]

Guarnaccia PJ, Martínez Pincay I, Alegría M, Shrout PE, Lewis-Fernández R, & Canino GJ (2007). Assessing Diversity Among Latinos:Results From the NLAAS. Hispanic Journal of Behavioral Sciences, 29(4), 510–534. doi:10.1177/0739986307308110 [PubMed: 19672330]

Hall JR, Balldin VH, Gamboa A, Edwards ML, Johnson LA, & O'Bryant SE (2018). Texas Mexican American adult normative studies: Normative data for the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). Developmental neuropsychology, 43(1), 27–35. [PubMed: 29185823]

Heaton AE, Gooding A, Cherner M, Umlauf A, Franklin D, Rivera Mindt M, Suarez PA, Artiola I Fortuni L, Heaton RK, & Marquine MJ (2020). Demographically-Corrected Norms for Tests of Fine Motor Skills in Spanish Speakers from the U.S.-Mexico Border Region. The Clinical Neuropsychologist, 34, XX–XX.

Heaton RK, Ryan L, & Grant I. (2009). Demographic influences and use of demographically corrected norms in neuropsychological assessment. Neuropsychological assessment of neuropsychiatric and neuromedical disorders, 3, 127–155.

Henrich J, Heine SJ, & Norenzayan A. (2010). Most people are not WEIRD. Nature, 466, 29. doi:10.1038/466029a [PubMed: 20595995]

Jacobs DM, Winston TD, & Polanco CL (1997). Assessment of verbal memory in Spanish-speaking elders: Development of two frequency-matched list learning tests. Journal of Clinical and Experimental Neuropsychology, 19(1), 119–125. [PubMed: 9071646]

Kamalyan L, Hussain MA, Diaz MM, Umlauf A, Franklin DR, Cherner M, Rivera Mindt M, Artiola i Fortuny L, Grant I, Heaton RK, & Marquine MJ (2020). Neurocognitive Impairment in Spanish-speaking Latinos Living with HIV in the US: Application of the Neuropsychological Norms for the US-Mexico Border Region in Spanish (NP-NUMBRS). The Clinical Neuropsychologist, 34, XX–XX.

Kern RS, Nuechterlein KH, Green MF, Baade LE, Fenton WS, Gold JM, . . . Seidman LJ (2008). The MATRICS Consensus Cognitive Battery, part 2: co-norming and standardization. American Journal of Psychiatry, 165(2), 214–220.

LaRue A, Romero LJ, Ortiz IE, Chi Lang H, & Lindeman RD (1999). Neuropsychological performance of Hispanic and non-Hispanic older adults: An epidemiologic survey. The Clinical Neuropsychologist, 13(4), 474–486. [PubMed: 10806461]

Lehtonen M, Soveri A, Laine A, Järvenpää J, de Bruin A, & Antfolk J. (2018). Is bilingualism associated with enhanced executive functioning in adults? A meta-analytic review. Psychological bulletin, 144(4), 394. [PubMed: 29494195]

Li P, Zhang F, Tsai E, & Puls B. (2014). Language history questionnaire (LHQ 2.0): A new dynamic web-based research tool. Bilingualism: Language and Cognition, 17(3), 673–680.

Llorente A. (2008). Principles of neuropsychological assessment with Hispanics: Theoretical foundations and clinical practice. New York: Springer Science and Business Media.

Luk G, & Bialystok E. (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. Journal of Cognitive Psychology, 25(5), 605–621. [PubMed: 24073327]

Marquez de la Plata C, Arango-Lasprilla JC, Alegret M, Moreno A, Tárraga L, Lara M, . . . Cullum CM (2009). Item analysis of three Spanish naming tests: A cross-cultural investigation. NeuroRehabilitation, 24(1), 75–85. [PubMed: 19208960]

Marquine MJ, Morlett Paredes A, Madriaga C, Blumstein Y, Umlauf A, Kamalyan L, Rivera Mindt M, Suarez PA, Artiola I Fortuni L, Heaton RK, & Cherner M. (2020a)Demographically-Adjusted Norms for Verbal Fluency Tests in a Spanish-Speaking Adult Population: Results from the Neuropsychological Norms for the US-Mexico Border Region in Spanish (NP-NUMBRS) Project. The Clinical Neuropsychologist, 34, XX–XX.

Marquine MJ, Yassai-Gonzalez D, Perez-Tejada A, Umlauf A, Kamalyan L, Suarez PA, Rivera Mindt P, Franklin D, Artiola I Fortuny L, Cherner M, & Heaton RK (2020b). Demographically-Adjusted Normative Data for the Wisconsin Card Sorting Test-64 Item Test in Spanish-Speaking Adults: Results from the Neuropsychological Norms for the US-Mexico Border Region in Spanish (NP-NUMBRS) Project. The Clinical Neuropsychologist, 34, XX–XX.

Marshall SC, Mungas D, Weldon M, Reed B, & Haan M. (1997). Differential item functioning in the Mini-Mental State Examination in English-and Spanish-speaking older adults. Psychology and Aging, 12(4), 718. [PubMed: 9416639]

Menon C, Hall J, Hobson V, Johnson L, & O'bryant SE (2012). Normative performance on the executive clock drawing task in a multi-ethnic bilingual cohort: a project FRONTIER study. International journal of geriatric psychiatry, 27(9), 959–966. [PubMed: 22052628]

Merriam-Webster (Ed.) (2018) Merriam-Webster Online.

Morlett Paredes A, Carrasco J, Kamalyan L, Cherner M, Umlauf A, Rivera Mindt M, Suarez PA, Artiola i Fortuni L, Franklin D, Heaton RK, & Marquine JM (2020). Demographically Adjusted Normative Data for the Halstead Category Test in a Spanish-Speaking Adult Population: Results from the Neuropsychological Norms for the US-Mexico Border Region in Spanish (NP-NUMBRS). The Clinical Neuropsychologist, 34, XX–XX.

Muñoz-Sandoval A, Woodcock RW, McGrew KS, Mather N, & Ardoino G. (2009). Batería III Woodcock-Muñoz. Ciencias Psicológicas, 3(2), 245–246.

O'Bryant SE, Edwards M, Johnson L, Hall J, Gamboa A, & O'jile J. (2018). Texas Mexican American adult normative studies: Normative data for commonly used clinical neuropsychological measures for English-and Spanish-speakers. Developmental neuropsychology, 43(1), 1–26. [PubMed: 29190120]

Ostrosky-Solis F, Ardila A, & Rosselli M. (1999). NEUROPSI: A brief neuropsychological test battery in Spanish with norms by age and educational level. Journal of the International Neuropsychological Society, 5, 413–433. [PubMed: 10439587]

Peña-Casanova J, Blesa R, Aguilar M, Gramunt-Fombuena N, Gómez-Ansón B, Oliva R, . . . Team, f. t. N. S. (2009). Spanish Multicenter Normative Studies (NEURONORMA Project): Methods and Sample Characteristics. Archives of Clinical Neuropsychology, 24(4), 307–319. doi:10.1093/arclin/acp027 [PubMed: 19549723]

Pontón MO, & Ardila A. (1999). The Future of Neuropsychology with Hispanic Populations in the United States. Archives of Clinical Neuropsychology, 14(7), 565–580. doi:10.1093/arclin/14.7.565 [PubMed: 14590571]

Pontón MO, Satz P, Herrera L, Ortiz F, Urrutia CP, Young R, . . . Namerow N. (1996). Normative data stratified by age and education for the Neuropsychological Screening Battery for Hispanics (NeSBHIS): Initial report. Journal of the International Neuropsychological Society, 2(2), 96–104. [PubMed: 9375194]

Puente AE, & Ardila A. (2000). Neuropsychological assessment of Hispanics In Handbook of cross-cultural neuropsychology (pp. 87–104): Springer.

Rabin LA, Paolillo E, & Barr WB (2016). Stability in Test-Usage Practices of Clinical Neuropsychologists in the United States and Canada Over a 10-Year Period: A Follow-Up Survey of INS and NAN Members. Archives of Clinical Neuropsychology, 31(3), 206–230. doi:10.1093/arclin/acw007 [PubMed: 26984127]

Rivera Mindt M, Marquine MJ, Aghvinian M, Morlett Paredes A, Kamalyan L, Suárez PA, Heaton AE, Scott T, Gooding A, Díaz-Santos M, Umlauf A, Taylor MJ, Artiola i Fortuni L, Heaton RK, & Cherner M, (2020). The Neuropsychological Norms for the US-Mexico Border Region in Spanish (NP-NUMBRS) Project: Considerations for Lifespan Research and Evidence-Based Practice. The Clinical Neuropsychologist, 34, XX–XX.

Rivera Mindt M, Marquine MJ, Aghvinian M, Scott TM, Cherner M, Morlett Paredes A, Kamalyan L, Taylor MJ, Umlauf A, Suárez PA, Artiola i Fortuny L & Heaton RK (2020b). Demographically-Corrected Norms for the Processing Speed Subtests of the WAIS-III in a Spanish-Speaking Adult Population Living in the U.S.-Mexico Border Region. The Clinical Neuropsychologist, 34, XX–XX.

Rivera Mindt M, Arentoft A, Coulehan K, Summers AC, Tureson K, Aghvinian M, & Byrd DA (2019). Considerations for the neuropsychological evaluation of culturally/linguistically diverse older adults The Handbook on the Neuropsychology of Aging and Dementia (2nd ed; pp. 25–48). New York, NY: Springer Science + Business Media.

Rivera Mindt M, Byrd D, Saez P, & Manly J. (2010). Increasing culturally competent neuropsychological services for ethnic minority populations: A call to action. The Clinical Neuropsychologist, 24(3), 429–453. [PubMed: 20373222]

Rivera Mindt M, Arentoft A, Germano KK, D'Aquila E, Scheiner D, Pizzirusso M, . . . Gollan TH (2008). Neuropsychological, cognitive, and theoretical considerations for evaluation of bilingual individuals. Neuropsychology review, 18(3), 255–268. [PubMed: 18841477]

Rodriguez-Jimenez R, Bagney A, Garcia-Navarro C, Aparicio A, Lopez-Anton R, Moreno-Ortega M, . . . Kern R. (2012). The MATRICS consensus cognitive battery (MCCB): co-norming and standardization in Spain. Schizophrenia research, 134(2–3), 279–284. [PubMed: 22192501]

Rosselli M, Ardila A, Florez A, & Castro C. (1990). Normative data on the Boston Diagnostic Aphasia Examination in a Spanish-speaking population. Journal of Clinical and Experimental Neuropsychology, 12(2), 313–322. [PubMed: 1692843]

Ryan C. (2013). Language Use in the United States: 2011. American Community Survey Reports. Retrieved January 23, 2015 http://www.census.gov/prod/2013pubs/acs-22.pdf

Salinas C, Edgar VB, Puente AE, & Ferraro FR (2016). Barriers and practical approaches to neuropsychological assessment of Spanish speakers In Ferraro FR (Ed.), Minority and cross-cultural aspects of neuropsychological assessment (pp. 229–257). New York and London: Taylor & Francis.

Scott TM, Morlett Paredes A, Taylor MJ, Umlauf A, Artiola I Fortuny L, Heaton RK, Cherner M, Marquine MJ, & Rivera Mindt M. (2020). Demographically-Adjusted Norms for the WAIS-R Block Design and Arithmetic Subtests: Results from the Neuropsychological Norms for the US-Mexico Border Region in Spanish (NP-NUMBRS) Project. The Clinical Neuropsychologist, 34, XX–XX.

Shi C, Kang L, Yao S, Ma Y, Li T, Liang Y, . . . Xu X. (2015). The MATRICS consensus cognitive battery (MCCB): Co-norming and standardization in China. Schizophrenia research, 169(1–3), 109–115. [PubMed: 26441005]

Stavans I. (2018). Latinos in the United States: What Everyone Needs to Know. New York: Oxford University Press.

Stricks L, Pittman J, Jacobs DM, Sano M, & Stern Y. (1998). Normative data for a brief neuropsychological battery administered to English-and Spanish-speaking community-dwelling

elders. Journal of the International Neuropsychological Society, 4(4), 311–318. [PubMed: 9656604]

Strutt AM, Ayanegui IG, Scott BM, Mahoney ML, York MK, & San Miguel Montes LE (2012). Influence of socio-demographic characteristics on DRS-2 performance in Spanish-speaking older adults. Archives of clinical neuropsychology, 27(5), 545–556. [PubMed: 22693138]

Strutt AM, Scott BM, Shrestha S, & York MK (2011). The Rey 15-item memory test and Spanish-speaking older adults. The Clinical Neuropsychologist, 25(7), 1253–1265. [PubMed: 21951176]

Suárez PA, Díaz-Santos M, Marquine MJ, Gollan T, Artiola i Fortuny L, Heaton RK, Cherner M, & the HNRC group (2020b). Role of English Fluency on Verbal and Non-Verbal Neuropsychological Tests in Native Spanish Speakers from the U.S.-Mexico Border Region using Demographically Corrected Norms. The Clinical Neuropsychologist, 34, XX–XX.

Suarez PA, Díaz-Santos M, Marquine MJ, Rivera Mindt M, Umlauf A, Heaton RKM, Grant I & Cherner M. (2020a). Demographically Adjusted Norms for the Trail Making Test in Native Spanish-speakers from the U.S.-Mexico Border Region. The Clinical Neuropsychologist, 34, XX–XX.

Suarez PA, Gollan TH, Heaton R, Grant I, Cherner M, & HNRC Group. (2014). Second-language fluency predicts native language Stroop effects: Evidence from Spanish–English bilinguals. Journal of the International Neuropsychological Society, 20(3), 342–348. [PubMed: 24622502]

United Nations Educational, Scientific and Cultural Organization. Institute for Statistics (UIS) (2016). Literacy among adult populations. In UNESCO e-Atlas of Literacy http://data.uis.unesco.org/Index.aspx?DataSetCode=EDULIT_DS&popupcustomise=tr ue&lang=en#

Uzzell B, Pontón M, & Ardila A. (2013). International handbook of cross-cultural neuropsychology. Mahwat, New Jersey: Lawrence Erlbaum Associates.

Table 1.

Normative studies conducted on Spanish-speaker adults living in the U.S. from most recent to oldest.

Study	Geographic Area	Sample Size (#)	Age (Mean and SD)	Education (Mean and SD)	Gender % female	Stratification/ adjustment of norms	Co-normed	Language (%)	Bilingulism	Tests
Hall et al., 2018 (TMAANS)	Texas/New Mexico border	136	53.61(8.89)	8.2 (3.97)	78.76%	Education and language of administration	Yes	ES: 50.73% SS: 49.26%	Not reported	1) The Repeatable Battery for the Assessment of Neuropsychological Status
O'Bryant et al., 2018 (TMAANS)	Texas	797	60.4 (8.6)	9.9 (4.6)	73.40%	Age and Education	Yes	ES: 48.30% SS: 51.69%	Not reported	1) Mini-Mental State Examination 2) The American National Adult Reading Test 3) Wechsler Memory Scale III 4) The Consortium to Establish a Registry for Alzheimer's Disease 5) The Rey Auditory Verbal Learning Test 6) The Executive Interview 25 7) An Executive Clock Drawing Task 1 & 2 8) Trail Making Test-A&B 9) Boston Naming Test 10) Controlled Oral Word Association Test 11) Animal Naming Test
Casaletto et al., 2016 (NIHTB-CB)	10 U.S. testing sites	408	44.1 (16.7)	10.7 (4.3)	65%	Age, Education and Gender	Yes	SS: 68% ES: 12.8% All tested in S	Not reported[1]	1) The National Institutes of Health Toolbox Cognition Battery
Strutt et al., 2012	Texas	157	61.7 (7.68)	11.8 (3.65)	97%	Age and Education	Yes	SS:100%	Not reported	1) ST-DRS-2
Menon et al., 2012	Texas/New Mexico border	446	CLOX 1: 58.6 (11.4) CLOX 2: 58.5 (11.2)	CLOX 1: 12.2 (3.8) CLOX 2: 12.1 (4.1)	CLOX 1: 74.2% CLOX 2: 73.2%	Age/ Age, education and gender	No	Not reported	Collected[2]	1) The CLOX
Strutt et al., 2011	Texas	130	Basic Ed: 59.3 (5.74) College Ed: 59.8 (6.06)	Basic Ed: 8.59 (2.44) College Ed:14.7 (1.30)	Basic Ed: 60.7% College Ed: 58.0%	Education	No	SS: 100%	Not reported	1) The Rey 15-Item Memory Test
Marquez de la Plata et al., 2009	Texas, Colombia, Spain	250	Nondemente: 72.9 (6.3) Demented: 77.8 (7.5)	Nondemented: 4.8 (3.8) Demented: 1.6 (1.8)	Nondemented: 64.3% Demented: 56.7%	Age and Education	No	SS: 100%	Not reported	1) The Texas Spanish Naming Test

Study	Geographic Area	Sample Size (#)	Age (Mean and SD)	Education (Mean and SD)	Gender % female	Stratification/ adjustment of norms	Co-normed	Language (%)	Bilingulism	Tests
Cherner et al., 2007	U.S./Mexico border regions of Arizona and California	127	37.5 (9.42)	9.75 (4.35)	64.50%	Education	No	SS: 100%	Not reported	1) Brief Visuospatial Memory Test-revised 2) Hopkins Verbal Learning Test-revised
Gonzalez et al., 2004	Sacramento	1,276	70.3 (6.8)	7.8 (5.4)	57.40%	Age, Education and gender	No	ES: 46.39% SS: 53.60%	Not reported	1) The Spanish English Animal Naming Test
Gonzalez et al., 2002	Sacramento	1,686	EE: 69.73 (6.63) SS: 70.76 (7.01)	EE: 10.79 (4.33) SS: 4.68 (4.38)	ES: 56.9% SS: 59.9%	Age, Education and Language	No	ES: 42.52% SS: 57.37%	Not reported	1) The Spanish-English Verbal Learning Test
Gonzalez et al., 2001	Sacramento	801	69.7 (7.2)	8.4 (5.1)	58.70%	Age, Education and Gender	No	L(E): 39.82% L(S): 46.19% NLW: 13.98%	Collected[3]	1) The Spanish-English Verbal Learning test (SEVLT)
Acevedo et al., 2000	Miami Beach, Florida, and Aventura, Florida	2332	ES: 69.1 (6.0) SS: 64.9 (7.7)	ES: 14.4 (2.5) SS: 13.4 (3.2)	ES: 74.0% SS: 69.2%	Age and Education	No	ES: 62% SS: 38%	Not reported	1) Animals, Vegetables, and Fruits
Artiola i Fortuny, et al., 1999 (The Batería Neuropsicológica en Español)	Mexico/U.S border and Spain	390	Mexico/U.S. border: 42.1 (13.5)	Mexico/U.S. border: 9.6 (6.1)	Mexico/U.S. border: 75%	Age and Education	Yes	SS	Not reported	1) Figure memory test 2) Spatial Span Test 3) Digit Span Test 4) Story memory tests 5) Verbal (list) Learning test 6) Wisconsin Card Sorting Test 7) Controlled Oral Words Association test (PMR) 8) Stroop Color and Words test
La Rue et al., 1999	Bernalillo County, New Mexico	797	NLW (Men): 74.1 (5.8) NLW (women): 73.8 (5.9) L (Men): 73.6 (6.5) L(Women): 72.9 (5.6)	NLW (Men): 14.1 (3.1) NLW (Women): 13.5 (2.5) H (Men): 9.7 (4.4) L(Women): 9.3 (3.9)	46.80%	Age, Education and Ethnicity	Yes	Tested in E: 79% Tested in S: 14% Tested in E and S: 7%	Collected[4]	1) Fuld Object Memory Evaluation 2) Digit Span 3) Category naming 4) Clock drawing 5) Color Trails
Stricks et al., 1998	Northern Manhattan	996	Tested in E: 75.8 (6.8) Tested in S: 74.7 (6.2)	Tested in E: 10.7 (3.9) Tested in S: 6.1 (4.2)	Tested in E: 67.7% Tested in S: 70.4%	Age and Education	Yes	Tested in E: 58.23% Tested in S: 41.76%	Not reported	1) Mini Mental State Examination 2) The Similarities subtest of the Wechsler Adult

Study	Geographic Area	Sample Size (#)	Age (Mean and SD)	Education (Mean and SD)	Gender % female	Stratification/ adjustment of norms	Co-normed	Language (%)	Bilingulism	Tests
										Intelligence Scale–Revised 3) The Identities and Oddities subtest of the Mattis Dementia Rating Scale 4) 15 item version of the Boston Naming Test 5) The Controlled Word association Test from the Multilingual Aphasia Examination 6) Category Fluency (animals, foods, and clothing) 7) Boston Diagnostic Aphasia Examination 8) The Selective Reminding Test 9) Form C and D of the original Benton Visual Retention Test 10) Rosen Drawing Test 11) Target-detection tasks
Jacobs et al., 1997	Northern Manhattan, New York	50	Form 1: 74.29 (5.75) Form 2: 75.85 (6.06)	6) The Pin Test Form 1: 10.62 (4.36)	Form 1: 63% Form 2: 65%	Age and Education	No	Form 1 SS: 67% Form 2 SS: 69%	Collected[5]	1) The Spanish Verbal Learning Test
Marshall et al., 1997	Sacramento and Winters California	753	71 (7.8)	8.5 (4.8)	56%	Age and Education	No	ES: 69.85% SS: 30.14%	Not reported	1) The Mini-Mental State Examination
Pontón et al., 1996 (The NeSBHIS)	Santa Ana, Pasadena, Montebello, Pacoima, and Van Nuys, California	300	38.4 (13.5)	10.7 (5.1)	60%	Age, Education and Gender	Yes	SS:70% Bilingual: 30%	Collected[6]	1) The Controlled Oral Word Association Test 2) The Pontón-Satz Boston Naming Test 3) The Rey-Osterreith Complex Figure Test Copy and Memory 4) Escala de Inteligencia Wechsler para Adultos: the Block Desing, the Digit Span, and the Digit Symbol test 5) Color Trails 1 and 2 6) The Pin test 7) The Raven's Standard Progressive Matrices

Notes: EE= English Speaking; SS= Spanish Speaking; E= English; S= Spanish; NLW = Non Latino White; L = Latino; TMAANS = Texas Mexican American Adult Normative Study; NIHTB-CB = National Institites of Health Tool Box-Cognitive Battery; NeSBHIS = Neuropsychological Screening Battery for Hispanics.

[1] Individuals included in this study elected to be tested in Spanish, but were not objectively assessed for English versus Spanish language proficiencies. As a result, this study may represent individuals with fairly heterogenous levels of Spanish proficiency and bilingualism, which can impact NIHTB-CB test performances.

[2] A self-report questionnaire was used to assess linguistic fluency and proficiency.

[3] Bilinguality in English and Spanish, defined by self report. Results in this study indicate that bilingual subjects had slightly poorer performance than monolinguals, but these differences were not present after adjusting for MMSE score in the SEVLT,

[4] Nearly all of their Latino participants were bilingual (self report). No analyses were performed to see if bilingualism had an effects on any of tests in this sudy.

[5] Self-report. Within the population studied, degree of bilingualism did not significantly impact test performance.

[6] Self-report. No analyses were performed to see if bilingualism had an effects on any of tests in this sudy.