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The Neuropsychological Norms for the U.S.-Mexico Border Region in Spanish (NP-NUMBRS) Project: Overview and considerations for life span research and evidence-based practice

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Abstract

Objective: This paper summarizes the findings of the Neuropsychological Norms for the U.S.-Mexico Border Region in Spanish (NP-NUMBRS) Project and offers a roadmap for future research.

Methods: The NP-NUMBRS project represents the largest and most comprehensive co-normed neuropsychological battery to date for native Spanish-speaking healthy adults from the U.S. (California/Arizona)-Mexico borderland region ($N = 254$; ages 19–60 years). These norms provide demographic adjustments for tests across numerous domains (i.e., verbal fluency, processing speed, attention/working memory, executive function, episodic memory [learning and delayed recall], visuospatial, and fine motor skills).

Conclusions: This project: 1) shows that the NP-NUMBRS norms consistently outperformed previously published norms for English-speaking non-Hispanic (White and African-American) adults in identifying impairment; 2) explores the role of Spanish-English bilingualism in test

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performance; and 3) provides support for the diagnostic validity of these norms in detecting HIV-associated neurocognitive impairment. Study limitations include the limited assessment of sociocultural variables and generalizability (e.g., other Latina/o populations, age limit [19–60 years]). Future research is needed to: 1) investigate these norms with U.S.-dwelling Spanish-speakers of non-Mexican heritage and other clinical subpopulations; 2) expand coverage of cognitive domains (e.g. language, visuospatial); 3) develop large normative datasets for children and older Latina/o populations; 4) examine how sociocultural factors impact performance (e.g., bilingualism, acculturation); 5) investigate these norms' diagnostic and ecological validity; and 6) develop norms for neurocognitive change across time. It is hoped that the NP-NUMBRS norms will aid researchers and clinicians working with U.S.-dwelling Spanish-speakers from the U.S.-Mexico borderland to conduct research and evidence-based neuropsychological evaluations in a more culturally responsive and ethical manner.

Keywords

Spanish-speakers; cultural neuropsychology; Latina/o; norms; demographic adjustments

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This article provides an overview of the *Neuropsychological Norms for the U.S.-Mexico Border Region in Spanish* (NP-NUMBRS) Project, highlights the important findings across the different papers in the series, and provides a roadmap for future research. The overarching aim of the NP-NUMBRS project was to provide demographically corrected (age, education, and sex) normative data for U.S.-dwelling Spanish-speaking adults (ages 19–60 years) from the U.S. (California/Arizona)-Mexico borderland region, with co-norming for a broad range of commonly used neuropsychological tests, across a wide array of cognitive domains (i.e. verbal fluency, processing speed, attention/working memory, executive function, verbal/visual learning and delayed recall, visuospatial skills, and fine motor skills). Due to the fact that Latinas/os of Mexican heritage comprises the largest U.S. Hispanic/Latina/o/Latinx subpopulation (US Census Bureau, 2018) and suffers significant health disparities pertinent to cognitive health (e.g. diabetes, cardiovascular burden), the NP-NUMBRS project offers urgently needed normative data for this understudied and underserved population (Perez-Escamilla, 2011; Rodríguez-Saldaña et al., 2002; Vega et al., 2009). Although population-specific norms with demographic adjustments are not the sole remedy for addressing current obstacles to valid neuropsychological evaluation and data interpretation with diverse populations, there are critical limitations with our current armamentarium of neuropsychological methods, and demographically adjusted normative data offer a viable and evidence-based approach to address these limitations at the present time (Manly & Echemendia, 2007).

In the spirit of collaborative science, this project was realized through the efforts of numerous investigators from across the U.S.A., Latin America, and Spain to provide a comprehensive collection of state-of-the-art demographically adjusted normative data for native Spanish-speaking adults of the U.S. (California/Arizona)-Mexico borderland region. This project represents the largest and most comprehensive normative study for U.S.-dwelling Spanish-speakers from the U.S. (California/Arizona)-Mexico borderland region to date with a sample size of 254 healthy adult Spanish speakers (ages 19–60 years) and a broad co-normed neuropsychological test battery.

This special issue includes a total of 15 papers. Six of the papers are dedicated to broader topics, including the following: an introductory paper (Marquine et al., 2020b); the state of neuropsychological test norms for Spanish-speaking Latinas/os in the U.S.A. (Morlett Paredes et al., 2020b); methodology and sample characteristics for the NP-NUMBRS study (Cherner et al., 2020); application of the NP-NUMBRS norms for detecting neurocognitive impairment (NCI) in Spanish-speaking Latinas/os Living with HIV in the U.S.A. (Kamalyan et al., 2020); effects of degree of Spanish-English bilingualism on verbal and non-verbal neuropsychological tests in native Spanish-speakers from the U.S.-Mexico border region (Suárez et al., 2020b); and this concluding overview paper (Rivera Mindt et al., 2020). In the remaining nine papers, demographically adjusted normative data developed by the NP-NUMBRS project are provided for the following seven neuropsychological domains and 15 measures: *verbal fluency* (PMR Lexical Fluency Test and Animal Fluency Test; Marquine et al., 2020a); *processing speed* (Trail Making Test-Part A [TMT-A], Suárez et al., 2020a and Wechsler Adult Intelligence Scale-III [WAIS-III] Digit Symbol Coding and Symbol Search subtests, Rivera Mindt et al., 2020); *attention/working memory* (Paced Auditory Serial Addition Test [PASAT] and WAIS-III Letter Number Sequencing Test [LNS], Gooding et al., 2020 and WAIS-R Arithmetic subtest, Scott et al., 2020); *executive functioning* (Halstead Category Test [HCT], Morlett Paredes et al., 2020a; Trail Making Test-Part B [TMT-B], Suárez et al., 2020; and Wisconsin Card Sorting Test-64 Item [WCST-64], Marquine et al., 2020c); *episodic memory, including measures of verbal/visual learning and delayed recall* (Brief Visuospatial Memory Test-Revised [BVMT-R] and the Hopkins Verbal Learning Test-Revised [HVLT-R]; Diaz-Santos et al., 2020); *visuospatial skills* (WAIS-R Block Design subtest; Scott et al., 2020), *and fine motor skills* (Finger Tapping Test and Grooved Pegboard Test; Heaton et al., 2020).

Prior to reviewing the key findings of the NP-NUMBRS project, it is important to note the efforts dedicated to the linguistic and cultural adaptation of the neuropsychological tests included in this battery. The NP-NUMBRS team approached the adaptation of the test materials with the objective of remaining as faithful as possible to the English language version of each test, while also translating in a linguistically/ culturally neutral manner that could be understood across the Spanish-speaking world and by persons across levels of formal education. This was done by assembling a group of native Spanish-speakers from among the study team who represented Mexico, South America (i.e. Argentina and Colombia), the Caribbean (i.e. Cuba and Puerto Rico), and Spain. The process included a comprehensive and iterative approach utilizing forward and backward translations in which each member translated each set of instructions and then circulated these translations for feedback until consensus was reached. Additional information regarding the linguistic/ cultural adaptation of the battery can be found in Cherner et al. (2020).

Key findings from the NP-NUMBRS Project

The key findings from the NP-NUMBRS Project highlight the importance of considering the demographic effects in neuropsychological test performance, the risk of over- or under-estimating impairment when applying ill-fitting norms to diverse samples, the importance of the role of language of assessment (i.e. effects of degree of Spanish-English bilingualism on neuropsychological test performance), and the implications for diagnostic validity.

As noted in Table 1 and consistent with prior research (Heaton et al., 2003, 2004; Norman et al., 2000; Tulsky et al., 2003), the current results revealed significant demographic effects of age, education, and/or sex on the raw scores for the tests included in this battery. Overall, age and education had significant effects on raw scores of almost all tests in the NP-NUMBRS battery, with younger age and higher education typically associated with better performance. Following application of the new NP-NUMBRS norms, which are adjusted for age, education, and sex, there were no demographic effects for the adjusted T-scores of any of the tests.

In order to illustrate the pitfalls of applying other population norms to interpret test performance, we underwent the exercise of re-calculating T-scores for our sample based on published demographic adjustments for U.S. non-Hispanic English-speakers. In terms of estimating impairment (defined as T-scores < 40), the results of this exercise suggest that the use of norms for non-Hispanic White English-speakers (Heaton et al., 2004) significantly overestimates impairment in native Latina/o Spanish-speakers in almost all cases. This finding was replicated repeatedly across a number of commonly used neuropsychological measures assessing the following domains: verbal fluency (Marquine et al., 2020a), processing speed (Rivera Mindt et al., 2020), attention/ working memory (Gooding et al., 2020), executive functioning (Marquine et al., 2020c), and episodic memory (verbal/visual learning and delayed recall) (Diaz-Santos et al., 2020). In contrast, the application of the non-Hispanic White norms yielded equivocal results with both over- and under-estimation of impairment in fine motor skills (Heaton et al., 2020). Together, these results suggest an overarching pattern of overestimating impairment across a broad array of neuropsychological domains, and point to the need for researchers and clinicians alike to utilize population-specific demographically adjusted norms when working with this population.

When applying non-Hispanic Black norms (Heaton et al., 2004; Norman et al., 2011) to this native Spanish-speaking sample, the pattern of results was more equivocal. On a number of tests, the use of the non-Hispanic Black norms underestimated impairment: verbal fluency (Marquine et al., 2020a) and fine motor skills (Heaton et al., 2020). In contrast, the non-Hispanic Black norms were comparable on tests of processing speed (Rivera Mindt et al., 2020) and attention/working memory (Gooding et al., 2020). Mixed results were observed in terms of executive function (Marquine et al., 2020c) and episodic memory (Diaz-Santos et al., 2020), in which the non-Hispanic Black norms sometimes under- or over-estimated impairment or yielded the comparable rates of impairment. Thus, applying non-Hispanic Black norms to this population runs the risk of misclassification in both directions (under- or over-estimating impairment) across most domains.

The descriptive characteristics of T-scores derived from norms developed for other groups in the U.S.A. to the present sample of Spanish-speakers (Table 2) is consistent with the misclassification of impairment described above. Most of the tests had means and standard deviations that notably deviated from the expected mean of ~50 and standard deviation of 10 that was accomplished with the NP-NUMBRS norms on the present sample. Furthermore, when norms for non-Hispanic Whites and Blacks were applied to the current sample, there continued to be significant effects of demographics on these T-scores (Table

2). Additionally, the application of different norms occasionally resulted in significantly different outcomes by sex, and in inconsistent directions. Such results indicate that these norms do not adequately adjust for the effects of these demographic influences in our sample.

Given this project's focus was on U.S.-dwelling Spanish-speakers, it was imperative to investigate possible influences on test performance associated with English proficiency. We did not set out to study the effects of bilingualism, per se, and did not design the project for that purpose. We recruited native Spanish-speakers who expressed that this was their primary language and excluded anyone for whom English was the dominant language. In addition to self-reported language preference, we administered a test of phonemic fluency in both languages and used these results a way to quantify objectively. As described in the paper by Suárez et al. (2020b), from these scores we calculated a relative English-to-Spanish fluency ratio. The results of the Suárez et al.'s (2020b) revealed that degree of bilingualism was associated with raw test performance in univariable analyses. Yet, after demographically corrected T-scores developed in the NP-NUMBRS project were applied, greater degree of bilingualism was significantly associated with better performance on only three of the 25 measures assessed, i.e. WAIS-III Digit Symbol, WAIS-III Symbol Search, and the Trail Making Test-Part B. Group comparisons showed that bilingual participants had significantly higher T-scores on these three tests, with small-to-medium effect sizes. Consistent with Mindt et al.'s (2008) bilingualism review, the subset of tests in which participants with a higher degree of Spanish-English bilingualism outperformed the monolingual group assessed domains such as processing speed, attention/working memory, and executive function. These findings are also consistent with evidence indicating higher ability of bilinguals in performing mental control and inhibition tasks, probably related to the need of constant inhibition of other languages in spontaneous speech (Calabria et al., 2018). However, interpretation of this finding is complicated by the large differences between the bilinguals and monolinguals on factors that were not adjusted for, including the aspects of schooling that might impact quality of the education (resources available at school, typical number of children in the classroom), and other SES-related factors (parental education, childhood socioeconomic status, need to work as a child). Overall, these findings suggest that while it might be important to consider sociocultural influences on cognitive test performance in this native Spanish-speaking sample with regard to some measures, the demographically corrected norms presented here correct for much of the observed effect of relative English fluency on neuropsychological test performance in this primarily Spanish-speaking sample.

To investigate the performance of the new norms with regard to diagnostic validity, we applied them to detecting HIV-associated NCI. The NP-NUMBRS norms resulted in impairment rates consistent with those observed in people with HIV within the U.S.A. and internationally. In contrast, rates of HIV-associated NCI differed significantly when non-Hispanic White and non-Hispanic Black norms (Heaton et al., 2003, 2004; Norman et al., 2011) were used, resulting in significant over- or under-estimation of impairment, respectively. This highlights the increased risk for inaccurate diagnostic conclusions when culturally and linguistically discrepant normative data and/or non-demographically adjusted normative data are utilized in clinical samples. Overall, the application of population-

specific normative adjustments to neuropsychological data for Spanish-speakers will ultimately result in more accurate and valid diagnostic conclusions, and may be beneficial for informing health care decisions.

Implications for the field and Latina/o health

Together, the 15 NP-NUMBRS Project articles provided in this special issue represent a significant contribution to the field for pragmatic, empirical, and ethical reasons. From a pragmatic perspective, the field of neuropsychology must maintain its relevance and viability in the twenty-first century by assuring the diagnostic validity of its methods to effectively serve the increasingly diverse U.S. population, which will be "majority minority" by the year 2050 (Colby & Ortman, 2015; Manly & Echemendia, 2007; Postal, 2018; Rivera Mindt et al., 2010; US Census Bureau, 2018). However, the NP-NUMBRS Project does not endorse the use of our norms as the sole approach to address current assessment and diagnostic challenges when working with diverse populations such as native Spanish-speakers. Instead, we recommend that neuropsychologists and allied health professionals integrate this evidence-based normative data approach with more nuanced sociocultural data (e.g. degree of bilingualism, acculturation, quality of education, SES, immigration history, country of origin; please see Rivera Mindt et al., 2008, 2010, 2020) to provide a more complete diagnostic picture of an examinee's cognitive performance within a sociocultural context. Please also see Marquine et al. (2020b) for further elaboration. Additionally, the NP-NUMBRS Project authors recognize the importance of considering how norms may or may not be the most appropriate for use when an individual has some dissimilarities and other atypical background characteristics, when compared to the test's normative population (e.g. a Spanish-speaking resident newly immigrated to the U.S.A.). Therefore, neuropsychologists should utilize the best available norms and sociocultural data in combination with their clinical judgments in carefully considering all available normative options (Scott et al., 2020).

Of note, U.S. Latinas/os suffer a disproportionate burden of health conditions (e.g. metabolic syndrome, toxin exposures) that increase their risk for minor and major neurocognitive disorders (Grineski et al., 2013; Heiss et al., 2014; Vieira et al., 2011; Yaffe et al., 2007), as well as a disproportionate burden of neurologic conditions (e.g. Alzheimer's disease, vascular dementia, HIV-associated NCI; Babulal et al., 2019; Hou et al., 2006; Marquine et al., 2018; Prejean et al., 2011; Rivera Mindt et al., 2014). Because of this disproportionate burden, it is imperative to generate and utilize culturally responsive science that minimizes the diagnostic misclassifications and over-estimation (or under-estimation) of impairments throughout the neuropsychological profile. For example, one potentially important consideration that is not addressed in the current norms is bilingualism, specifically degree of Spanish-English bilingualism. The results from the bilingualism paper in this special issue (Suárez et al., 2020b) suggest that degree of bilingualism level could affect the interpretation of cognitive test performance, although interpretation of such effects is complicated by the evidence that bilingualism among Spanish-speakers in the U.S.A. frequently is associated with better educational opportunities and a number of other background factors that could lead to improved test performance. Nevertheless, given the absence of such linguistic adjustments at the present time, the information presented in the

paper by Suárez et al. (2020b) may be helpful for determining how to best consider the impact of degree of Spanish-English bilingualism among native Spanish-speakers on the NP-NUMBRS battery. Readers are encouraged to consider the following papers for further information and guidance on how to incorporate linguistic information into research and evidence-based practice: Miranda et al. (2016), Rivera Mindt et al. (2008), and Gollan et al. (2007). In sum, although the use of even the best available norms should be guided by clinical judgments about their applicability in any specific case, the NP-NUMBRS co-normed tests with the current demographic corrections serve as a useful tool for addressing significant disparities in brain and cognitive health by improving the assessment, diagnosis, and ultimately treatment for this important U.S. population.

From an empirical perspective, the NP-NUMBRS project goes beyond simply offering normative data to the field. Specifically, a number of articles in this special issue provide much needed sociocultural context and methodological rigor to advance the field. For instance, Morlett Paredes et al.'s (2020b) article on the state of neuropsychological test norms for Spanish-speaking Latinas/os in the U.S.A. highlights the normative work accomplished to date and the remaining lacunae in the literature and our field. In doing so, these authors help provide a road map for needed future research. Suárez et al.'s (2020b) bilingualism paper contributes to the growing body of literature on the critical need to integrate the role and impact of sociocultural factors, such as Spanish-English bilingualism and a number of frequently associated background characteristics, on neuropsychological functioning. Since none of these potentially important factors exist in isolation, it is a challenge to the field to identify which aspects of sociocultural and economic background differences are the most responsible for test performance differences that are not accounted for by the typical demographic corrections (e.g. years of education completed). The NP-NUMBRS project did attempt to provide more than the usual granularity regarding such potentially important background differences (e.g. years of education in country of origin, language use, childhood SES; please see Table 5 in Cherner et al. [2020]). This level of granularity is important as it provides those who utilize these norms with a better understanding of the generalizability of these norms and their limitations, which has been a significant limitation to many past normative datasets. Moreover, Cherner and Marquine et al.'s (2020) methodology papers provide researchers and clinicians with an overview of the numerous sociocultural variables (e.g. linguistic, educational, socioeconomic) that can and should be queried and considered when working with diverse populations. Lastly, Kamalyan et al. (2020) diagnostic validity paper further demonstrates that utilizing appropriate normative data significantly improves diagnostic classification (Manly, 2008; Manly & Echemendia, 2007; Smith et al., 2003).

From an ethical perspective, neuropsychologists, like all psychologists, are obliged to practice in a culturally responsive manner to: 1) ensure the inclusion of all persons, including those of diverse backgrounds, such as U.S. Latinas/os, into research and clinical service, and 2) utilize the best available tests and normative data to ensure the psychometric integrity of our neuropsychological evaluations (American Psychological Association, 2010, 2017; Rivera Mindt et al., 2010). However, these ethical mandates can often exist in dynamic tension within the field of neuropsychology, as our assessment methods armamentarium continue to evolve and *hopefully* catch up to the demographic and "on

the ground" realities of conducting neuropsychological research and practice in the U.S.A. In response, the NP-NUMBRS project is positioned to aid neuropsychological researchers, clinicians, and allied health professionals working with (or interested in working with) Spanish-speakers residing in the U.S. (California/ Arizona)-Mexico borderland region.

Notably, this research cannot be considered detached from the sociocultural zeitgeist. Current U.S. immigration and health policies sometimes run counter to ethics, ethos, and aspirations of our field, and are negatively affecting the population for whom these norms were developed to benefit. This is a vulnerable population, which must be considered with great care to ensure the highest level of dignity, respect, and ethical treatment in all areas of neuropsychological research, evidence-based practice, and service.

Strengths, limitations, and future directions

The NP-NUMBRS Project has some key strengths and limitations that merit emphasis. With regard to study strengths, to our knowledge this is the first study to provide demographically adjusted normative data on a battery of co-normed standardized tests for a well-characterized sample of U.S.-dwelling Spanish-speakers living in the U.S. (California/Arizona)-Mexico borderland region. This is a significant contribution to the field considering that Latinas/os of Mexican origin comprises the largest proportion of Latinas/os in the U.S.A. (US Census Bureau, 2018), with a large proportion being primarily Spanish-speaking. To that end, the current normative data are poised to enhance both research and clinical care for this population. Additionally, the NP-NUMBRS team made considerable efforts to use linguistically "neutral Spanish" that was easily understood by diverse Spanish-speaking groups, and to provide detailed characterization of the sociocultural characteristics of the normative sample. Furthermore, as delineated in Cherner and Marquine et al. (2020), the methodology utilized for the development of the NP-NUMBRS norms allows consideration of both linear and nonlinear effects of demographic factors, and developed a useful digital calculator tool to aid in computing norms. Together, these NP-NUMBRS normative data can improve diagnostic classification and facilitate the identification of cognitive strengths and weaknesses in native Spanish-speakers from the U.S.-Mexico borderland region.

With regard to study limitations, the generalizability of the current findings to other Spanish-speaking populations, even within the U.S.A., has not been evaluated and cannot be assumed. Of particular concern, Latinas/os of Puerto Rican heritage are at increased risk for worse health outcomes (e.g. diabetes, hypertension, asthma) compared to other Latina/o subpopulations residing in the U.S.A. (Arroyo-Johnson et al., 2016; Steinberg et al., 2017; Tucker et al., 2010), and one study suggests that they are significantly greater risk for HIV-associated NCI compared to Latinas/os of U.S./Mexico borderland region (Marquine et al., 2018). However, because no population-specific norms currently exist for U.S.-dwelling people of Puerto Rican heritage, and since there was not an HIV-uninfected comparison group in the latter study, it is unclear whether some of the differences could be due to norm generalizability issues. Other potential limitations of the current norms are the facts that the data were collected a number of years ago (Cohort 1 – 1998–2000; Cohort 2 – 2006–2009), which raises the question as to whether a Flynn's (2007) effect and/or

changes in the sociocultural characteristics of the population in the border region over time might impact their applicability in more current cohorts. While this cannot be ruled out, our findings indicate that there were no significant differences in test performance between Cohorts 1 and 2 on all tests except for the WAIS-III Letter Number Sequencing, for which the effect was small (see Gooding et al., 2020 for details). These finds are inconsistent with the notion of significant changes in performance over time. Future research investigating the applicability of the NP-NUMBRS data to current samples in the region will best address this question. Furthermore, the normative sample had a restricted age range (19–60 years old); clearly, more research is needed to extend the age range for which these norms can be used to facilitate life span research and practice in this population. Although the NP-NUMBRS battery co-normed here is fairly extensive, it has limited measures of language function and visuospatial skills. Furthermore, there were no tests in the battery which can be utilized as estimates of premorbid cognitive functioning (e.g. an oral reading test). Lastly, given that numerous sociocultural variables (i.e. nation of origin, acculturation) are known to significantly impact cognitive test performance (Rivera Mindt et al., 2010; Saez et al., 2014), an important limitation of this project is that the associations between sociocultural variables and test performance in this study were not analyzed. The reason for this is that the authors of this series of manuscripts believe that these analyses are beyond the scope of this normative data project given the complexity of sociocultural factors and numerous other potential confounding factors. A separate series of manuscripts is planned to address this important and complex issue. Relatedly, while current findings show misclassification of impairment when utilizing other sets of norms based upon groups with different races, ethnicities, and language backgrounds, the current project was not designed to examine the factors that might underlie these differences. Thus, the factors driving these differences in impairment when utilizing different sets of norms is also beyond the scope of the current project, but is an area that merits further attention.

Future research is needed to: 1) investigate the sensitivity and specificity of the current norms for use with other diverse, U.S.-dwelling Spanish-speaking healthy and clinical subpopulations (e.g. Caribbean, Central American, South American); 2) develop additional large normative datasets for use with children and older adults in this and other Latina/o populations; 3) develop systematic approaches to incorporate degree of bilingualism and associated background factors into future normative data projects and clinical interpretation of data; 4) understand the effects of potentially important sociocultural factors that could impact neuropsychological test performance (e.g. country of origin, level of acculturation, quality of education, age of immigration) in this and other Latina/o populations; 5) further investigate the validity of the norms in clinical populations and their utility for predicting everyday functioning; and 6) develop norms for neurocognitive change across time in this and other Spanish-speaking groups in the U.S.A.

Conclusions

NP-NUMBRS is the largest project to co-norm a relatively comprehensive neuropsychological test battery for U.S.-dwelling Spanish-speakers from the U.S. (California/ Arizona)-Mexico borderland region. Despite this project's limitations, NP-NUMBRS project represents an important step forward in neuropsychology by providing

demographically adjusted normative data for a very substantial underrepresented and underserved population. Of note, these normative data are intended to be integrated with sociocultural data (e.g. bilingualism, acculturation, country of origin; please see Rivera Mindt et al., 2008, 2010, 2020). It is hoped that utilization of these NP-NUMBRS norms and expanded sociocultural background data will facilitate increased future research and enhance the practice of clinical neuropsychology with this important study population.

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Table 1.

Overview of demographic characteristics that were significantly correlated with raw test scores.

Demographic characteristics	Neuropsychological test raw scores
Age	Animal Fluency *; BVMT-R **; Grooved Pegboard **; HCT **; HVLT-R *; Letter Fluency (PMR) *; Trail Making Test - Parts A and B **; WAIS-III Digit Symbol Coding **, Letter Number Sequencing **, & Symbol Search **; WAIS-R Arithmetic ** & Block Design **; WCST **
Education	Animal Fluency *; BVMT-R **; HCT **; HVLT **; Finger Tapping **; Grooved Pegboard **; Letter Fluency (PMR) *;PASAT-50 & –200 **; Trail Making Test - Parts A ** & Trails B **; WAIS-III Digit Symbol Coding **, Letter Number Sequencing **, & Symbol Search **; WAIS-R Arithmetic ** & Block Design **; WCST **
Sex	Finger Tapping **; HCT **; PASAT-50 & –200 **; WAIS-R Arithmetic ** & Block Design **

Notes. BVMT-R = Brief Visuospatial Memory Test-Revised; HCT = Halstead Category Test; HVLT-R = Hopkins Verbal Learning Test-Revised; PASAT = Paced Auditory Serial Addition Test; WAIS = Wechsler Adult Intelligence Test; WCST = Wisconsin Card Sorting Test.

* $p < .05$

** $p < .01$.

Table 2.

Association of demographic characteristics with demographically adjusted T-scores developed for non-Hispanic White and Black adults and applied to the present sample of native Spanish-speakers.

Domain	Test	NH White norms		NH Black norms	
		M(*SD*)	Demographic effects[a1]	*M*(*SD*)	Demographic effects[a2]
Verbal Fluency	Letter Fluency	46.93 (10.39)	age$^{(+)***}$; educ$^{(+)*}$	53.82 (10.71)	age$^{(+)***}$
	Animal Fluency	46.83 (9.90)	age$^{(+)***}$	55.54 (8.88)	age$^{(+)**}$; sex$^{(F>M)*}$
Processing Speed	Trail Making Test A	46.08 (10.11)	—	48.78 (9.78)	educ$^{(+)**}$; sex$^{(M>F)*}$
	WAIS-III Digit Symbol	47.50 (8.89)	age$^{(-)***}$; sex$^{(M>F)*}$	50.05 (9.14)	age$^{(-)**}$; educ$^{(+)***}$; sex$^{(M>F)*}$
	WAIS-III Symbol Search	45.64 (8.67)	age$^{(-)*}$; educ$^{(+)*}$	50.51 (9.81)	educ$^{(+)***}$
Attention/ Working	PASAT-50	45.13 (10.68)	age$^{(+)*}$	51.13 (10.67)	age$^{(+)**}$; sex$^{(M>F)**}$
Memory	PASAT-200 WAIS-III L-N Sequence WAIS-R Arithmetic[b]	43.98 (11.44) 44.00 (8.57) —	age$^{(+)**}$; sex$^{(M>F)*}$ educ$^{(+)**}$ —	49.87 (11.43) 49.05 (8.77) —	age$^{(+)**}$; sex$^{(M>F)**}$ educ$^{(+)***}$ —
Executive	Trail Making Test B	44.11 (11.27)	educ$^{(+)*}$	49.20 (11.22)	educ$^{(+)***}$
Function	WCST-64 (PR)	41.21 (13.39)	age$^{(+)*}$; educ$^{(+)*}$	49.49 (11.13)	—
	Halstead Category Test	40.51 (8.59)	sex$^{(M>F)***}$	45.57 (9.59)	educ$^{(+)***}$; sex$^{(M>F)**}$
Episodic Memory (Learning and Delayed Recall)	HVLT-R Learning HVLT-R Delayed BVMT-R Learning BVMT-R Delayed	44.58 (10.75) 42.85 (10.64) 46.06 (9.47) 48.37 (11.51)	age$^{(-)*}$; educ$^{(-)***}$ educ$^{(-)***}$; sex$^{(M>F)**}$ educ$^{(+)***}$; sex$^{(M>F)***}$ age$^{(-)*}$; educ$^{(+)***}$	48.12 (9.33) 48.41 (8.74) 51.87 (10.63) 55.07 (12.44)	— age$^{(-)*}$ educ$^{(+)**}$; sex$^{(M>F)***}$ educ$^{(+)**}$; sex$^{(M>F)**}$
Visuospatial Skills	WAIS-R Block Design[b]	—	—	—	—
Fine Motor Skills	Grooved Pegboard (D) Grooved Pegboard (ND)	51.28 (10.21) 47.31 (9.76)	— —	58.52 (10.21) 56.64 (10.76)	age$^{(-)**}$; sex$^{(F>M)*}$ age$^{(-)*}$; sex$^{(F>M)*}$
	Finger Tapping (D) Finger Tapping (ND)	52.45 (8.87) 53.95 (8.96)	sex$^{(F>M)*}$ educ$^{(+)*}$	50.59 (7.81) 51.45 (8.09)	age$^{(-)***}$ age$^{(-)**}$; sex$^{(F>M)*}$

Notes.

[a] Demographic characteristics (age, education, gender) that are significantly associated with TS derived from non-Hispanic White (a1) and Black (a2) norms when applied to the current sample of Spanish-speakers

[b] Separate demographically-adjusted norms for non-Hispanic White and Black adults were not available for the WAIS-R Arithmetic and Block Design subtests

$^{(+)}$ denotes positive association with T-Scores

$^{(-)}$ denotes negative association with T-scores

$^{(F>M)}$ females obtained higher T-scores than males

(M>F) males obtained higher T-scores than females

BVMT-R = Brief Visuospatial Memory Test-Revised; D = dominant; educ = education; HCT = Halstead Category Test; HVLT-R = Hopkins Verbal Learning Test-Revised; L-N = Letter-Number; ND = non-dominant; PASAT = Paced Auditory Serial Addition Test; PR = Perseverative Responses; WAIS = Wechsler Adult Intelligence Test; WCST = Wisconsin Card Sorting Test.

* $p<.05$

** $p<.01$

*** $p<.001$.