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Demographically-Adjusted Norms for the Processing Speed Subtests of the WAIS-III in a Spanish-Speaking Adult Population: Results from the Neuropsychological Norms for the U.S.-Mexico Border Region in Spanish (NP-NUMBRS) Project

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Abstract

Objective—The Wechsler Adult Intelligence Scale (WAIS) processing speed subtests are among the most ubiquitous indices of processing speed in the field. The aim of this study was to develop and examine demographically-adjusted normative data for Spanish language versions of the WAIS-III Digit Symbol Coding (DSC) and Symbol Search (SS) subtests for US-dwelling Spanish-speakers living in the US/Mexico border region.

Methods—The sample included 203 healthy participants who were part of the larger *Neuropsychological Norms for the US-Mexico Border Region in Spanish* (NP-NUMBRS) project (DSC: $n = 201$; SS: $n = 200$).

Results—Older age and higher education were both related to lower scores on the DSC and SS subtests (all *ps* <.0001). There were no significant effects for gender (all *ps* > .05). Raw-to-scaled score conversions were calculated for both subtests, and fractional polynomial equations were derived to compute demographically-adjusted T-scores accounting for age, education, and gender for each subtest and the Processing Speed Index. Published norms for English-speaking non-Hispanic white adults slightly overestimated impairment rates (T-scores <40) on both the DSC and SS subtests, while the norms for English-speaking non-Hispanic Black/African Americans and the new NP-NUMBRS norms Spanish-speakers both yielded impairment rates that fell within expected limits for healthy controls (i.e., 13% - 14%).

Conclusions—This study suggests that population-specific normative data can improve the diagnostic validity of these measures for U.S.-dwelling Spanish-speakers living in the US/Mexico

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border region. Future research is needed to investigate the utility of these norms for other U.S.-dwelling Spanish-speaking subpopulations (e.g., Caribbean, Central American, South American).

Keywords

Hispanics; Latina/o; Latinx; normative data; cognition

Introduction

Processing speed refers to how quickly an individual can process information, essentially one's efficiency in executing cognitive tasks. Bradyphrenia, or slowed processing speed, is one of the most sensitive indicators of brain damage and dementia (Crowe et al., 1999; Lezak et al., 2012; Russell, 1972; Wechsler, 1997), and thus a critically important aspect of neuropsychological evaluations. The processing speed subtests of the Wechsler Adult Intelligence Scale (WAIS) are among the most ubiquitous indices of processing speed in the field. The WAIS-III (Wechsler, 1997) consists of the Digit Symbol Coding and Symbol Search subtests, which entail processing visually presented information and responding to it within a specific time frame (120 seconds). Both the Digit Symbol Coding and Symbol Search subtests are measures of cognitive processing speed and visual motor coordination. The Digit Symbol Coding subtest of the WAIS-III (Wechsler, 1997) involves the presentation of a key filled with a series of symbols corresponding to digits. The symbol search subtest of the Wechsler Adult Intelligence Scale-III (WAIS-III; Wechsler, 1997) requires the examinee to indicate by drawing a slash through the appropriate box whether either of two target symbols is present in a search group of five symbols.

Demographic effects exist in varying magnitudes for each individual subtest of the WAIS-III and have been documented extensively for age, education, sex, and race/ethnicity, including the processing speed subtests (Heaton, Matthews, Grant, & Avitable, 1996; Heaton, Taylor, & Manly, 2003; Norman, Evans, Miller, & Heaton, 2000; Tulsky et al., 2003). In order to reduce the impact of such demographic factors on neuropsychological test performance, demographically-adjusted normative data is used to provide a better understanding of one's performance relative to demographically similar individuals (Heaton et al., 2004). Research with the WAIS-III normative sample ($N = 2{,}450$), which was comprised of healthy controls, revealed that age was negatively associated with both Processing Speed subtests of the WAIS-III, while education was positively associated with both subtests, and effect sizes were large in all cases (Tulsky et al., 2003). With regard to sex, females have been found to perform slightly better than males on the Processing Speed subtests of the WAIS-III (Heaton, Taylor, & Manly, 2003; Tulsky et al., 2003). Lastly, with regard to race/ethnicity, research suggests that non-Hispanic whites score the highest, Latinas/os obtain intermediate scores, and African Americans score the lowest (Boone, Victor, Wen, Razani, & Pontón, 2007; Heaton, Taylor, & Manly, 2003; Tulsky et al., 2003). Together these findings highlight the need for demographically-adjusted normative data for valid interpretation of the WAIS-III processing speed subtests. This issue is further highlighted with regard to Spanish-speaking Latinas/os.

Within Spanish-speaking populations, the WAIS-III has been the most well investigated version of the WAIS (Duggan et al., 2018). In the past twenty years, three Spanish language versions of the WAIS-III were developed: Mexico (WAIS-III-M; Wechsler, 2003), Puerto Rico (Escala de Inteligencia de Wechsler para Adultos-Tercera Edition; EIWA-III-PR; Wechsler, 2008), and Spain (WAIS-III-S; Wechsler, 2001). When comparing performance on the Digit Symbol subtest among the three Spanish language WAIS-III batteries and the United States (U.S.) English language WAIS-III, mean performance was lower across most age groups in the Spanish-language versions (Funes, Hernandez Rodriguez, Lopez, 2016). The Mexican subsamples scored lower than the Spanish subsamples in most age ranges, and the Mexican and Spanish subsamples had significantly lower educational attainment than the US-based WAIS-III normative sample. Additionally, the Mexican subsample scored significantly lower than the Spanish sample on Digit Symbol test performance (Funes, Hernandez Rodriguez, Lopez, 2016). These findings suggest that while applying the Spanish language WAIS-III norms may underestimate deficits found in Spanish-speaking populations, the application of English language WAIS-III norms may overestimate deficits (Funes, Hernandez Rodriguez, Lopez, 2016). The overestimation of deficits when applying the English language WAIS-III norms to Spanish-speaking populations may be due to the differing educational attainments of the normative samples; the Spanish-language WAIS-III samples reflect a lower educational level than the US WAIS-III sample (Funes, Rodriguez, & Lopez, 2016). These differences in the normative samples may be due to a number of other factors, including access to health care, socioeconomic status, and the presence of conditions known to affect cognition (e.g. vascular disease; Funes, Rodriguez, & Lopez, 2016), as well as cultural differences in approaches to test performance (Rivera Mindt et al., 2010).

Given the limitations of existing English and Spanish language norms for the WAIS-III battery for Spanish-speakers, there is a clear need to further develop well-characterized normative databases for specific Spanish-speaking populations in the US. The aim of the current study was to develop and examine demographically-adjusted normative data for the Spanish language versions of the WAIS-III Digit Symbol Coding and Symbol Search subtests for US-dwelling Spanish-speakers living in the US/Mexico border region. This is a particularly important subpopulation to focus on since Latinas/os of Mexican origin comprise the largest proportion of Latinas/os in the U.S. (US Census Bureau, 2018). Latinas/os from the border region may differ significantly from other Latinas/os, with disproportionate effects of certain health conditions (e.g. diabetes mellitus, cervical cancer) and communicable diseases (e.g. tuberculosis) (United States-Mexico Border Health Commission, 2010). Additionally, the continued and rapid growth of this border population poses various unique challenges such as barriers in accessing healthcare, poverty, and low socioeconomic status. We also examined rates of neurocognitive impairment derived from the present demographically-adjusted Spanish-speaking norms and from applying existing norms for English-speaking adults to our sample.

Methods

Participants and Procedures

The study sample included 203 healthy, native Spanish-speaking participants, who were part of the larger *Neuropsychological Norms for the US-Mexico Border Region in Spanish* (NP-NUMBRS) project *(N* = 254). Participants were recruited from the US-Mexico border regions of Arizona (*n* = 63) and California (*n* = 140), and data were collected in two waves: from 1998 to 2000 (Cohort 1: *n* = 132) and from 2006 to 2009 (Cohort 2: *n* = 71). In order to be eligible for participation in either study, volunteers had to be generally healthy men and women between the ages of 18 and 60 who were native Spanish-speakers and lived in the U.S. at least part of the time. Exclusionary criteria for the study included any central nervous system disorder or other serious medical condition; serious psychiatric conditions (e.g., psychosis, bipolar disorder); and any lifetime substance dependence. Participants were also excluded if English was their dominant language. Recruitment was conducted through the use of flyers posted at community settings patronized by Spanish-speakers and in-person presentations conducted by staff at Latina/o serving community and health-care organizations in both San Diego, CA and Tucson, AZ. For further information regarding the methodology of the NP-NUMBRS project and sample characteristics (e.g., age, education), see Cherner et al. included in this special issue.

A total of 201 participants completed the WAIS-III Digit Symbol subtest, 200 completed the Symbol Search subtest, and 198 completed both subtests. These subtests were administered following standardized procedures consistent with the WAIS-III-M (Wechsler, 2003).

The Digit Symbol subtest of the WAIS-III (Wechsler, 1997) is a timed pencil and paper test in which participants need to place, as fast as they can, a symbol that correctly corresponds to a digit given a code provided. This involves the presentation of a key filled with a series of symbols corresponding to digits 1 – 9. Below the key are a series of numbers 1 – 9 repeated multiple times in random order, with a blank space below each number. After completing a set of practice items, the examinee is allotted a period of 120 seconds to fill the symbol that corresponds to the appropriate number in the blank space. Examinees are instructed to go as fast as they can and complete the items as accurately as possible. This is a measure of psychomotor and processing speed. Total administration time is about 3 – 5 minutes.

The Symbol Search subtest of the WAIS-III (Wechsler, 1997) is also a timed pencil and paper test, which requires the examinee to indicate by drawing a slash through the appropriate box whether either of two target symbols is present in a search group of five adjacent symbols. After completing a set of practice items, the examinee is allotted a period of 120 seconds to complete as many items as possible. Total administration time is about 3 – 5 minutes.

Normative data on the following scores were developed:

Digit Symbol Total Score. The total score for the Digit Symbol subtest is the total number of correct entries.

Symbol Search Total Score. The total score for the Symbol Search subtest is the number of items incorrect subtracted from the number of items correct.

Processing Speed Index (PSI). The PSI is derived from the combined performance on the Digit Symbol and Symbol Search subtests.

See Cherner, Marquine and colleagues (this issue) for further details on participants and procedures.

Statistical Analyses

We investigated the distribution of raw scores on the Digit Symbol and Symbol Search tests via Shapiro-Wilk tests, and examined the association of demographic variables (age, education and gender) with these raw scores via Spearman ρ (for age and education) and Wilcoxon-rank sum tests (for gender). We also examined interaction effects of demographics on raw scores via a series of linear regression models with two-way interaction terms for demographic variables (age X gender, age X education, gender X education). Raw scores on individual tests were converted to Scale Scores. Age-adjusted Standard Scores (mean of 100, SD of 15) were developed for each test based on the Scale Scores. T-score values were also calculated for each test based on the Scale Scores by applying the fractional polynomial equations controlling for age, education, and sex as described in Cherner et al. (this issue). In order to develop a Processing Speed Index, the age-adjusted Standard Scores from Symbol Search and Digit Symbol were added together, and the resulting distribution was converted to a distribution with a mean of 100 and SD of 15 to produce an age-adjusted PSI. The resulting age-adjusted PSI scores were then converted into fully demographically-adjusted PSI T-scores using fractional polynomials with age, education, and sex as the predictors similar to procedures described above for the individual tests. We then examined the descriptive characteristics of the resulting T-scores for individual tests and the PSI, and their distribution via Shapiro-Wilk tests. We investigated the association of age and education with the newly developed T-scores (via Pearson product moment correlation coefficients), and the association of sex and these T-scores (via independent samples t-tests). We also compared T-scores by site (Arizona and California) and time when the data were collected (Cohorts 1 and 2) via independent sample t-tests

Lastly, the Digit Symbol and Symbol Search Total Correct raw scores were utilized to compute T-scores based on the published norms for English-speaking non-Hispanic White (NHW) and non-Hispanic Black/African American (NHBAA) adults in the U.S (Heaton et al., 2003). Both the published norms and newly developed norms were used to calculate rates of "impairment." T-scores below 40 were considered "impaired" (Taylor & Heaton, 2001). Considering the normalized distribution of T-scores, approximately 14–16% of the sample should fall within the "impaired range." McNemar's tests were used to compare rates of impairment using our developed Spanish-speaking norms and published norms for English-speaking non-Hispanic Whites and non-Hispanic Blacks/African Americans. A *p*-value of .05 was used as the level of significance for all analyses.

Results

Demographic Characteristics of the Norming Sample

Table 1 summarizes the demographic characteristics of the entire norming sample for this study ($N = 203$). Similar to the overall NP-NUMBRS cohort, this sample's age ranged from 19 to 60 years (19–29; 30–39; 40–49; 50–60). Education ranged from 0 to 20 years (M (SD) = 10.67 (4.34)), and a little over half of the sample was female (59%). Table 1 includes additional educational, social, and language information to delineate the sociocultural characteristics of the study sample. Of note, for 98% of the sample, Spanish was their first language (Cherner et al., in press). The results of performance-based measures (i.e., verbal fluency measures in English and Spanish) revealed that approximately two-thirds of the sample was Spanish language dominant and the remaining approximately one-third were bilingual.

Raw scores to scale scores conversions

Table 3 shows descriptive characteristics of raw scores on Digit Symbol and Symbol Search Total Scores. Results from Shapiro-Wilk tests indicated neither of the variables were normally distributed in raw scores. Table 4 shows the associations between the raw scores with the demographic variables. There were small-to-medium effects of age, and large effects of education on both the Digit Symbol and Symbol Search Total Correct raw scores. There were no significant main effects of gender on any of the raw scores. In addition, there were no significant two-way interaction effects of demographic characteristics on the Digit Symbol or Symbol Search Total Correct raw scores (all $ps > .10$). Lastly, Table 5 shows the raw-to-scale score conversions for the Digit Symbol and Symbol Search Total Correct scores, which resulted in normalized distributions for both subtests.

Age-adjusted standard scores for individual tests

Table 6 shows the equations used to compute age-adjusted Standard Scores for the Digit Symbol and Symbol Search based on the scale scores for these tests (presented in Table 5). The Digit Symbol and Symbol Search Standard Scores were normally distributed, and had a mean of 100 and a SD of 15. Standard scores ranged from 56 to 137 for Digit Symbol Total Correct and from 62 to 130 for Symbol Search Total Correct. Pearson product moment correlation coefficients showed no significant effect of age on the Standard Scores ($ps > .95$).

Fully demographically-adjusted T-Scores for individual tests

Table 7 illustrates the T-score equations used to compute individual T-Scores based on scale scores for the Digit Symbol and Symbol Search (presented in Table 5). The Digit Symbol and Symbol Search T-score values were normally distributed, and had a mean of 50 and a SD of 10. T-scores ranged from 26 to 79 for Digit Symbol Total Correct and from 22 to 76 for Symbol Search Total Correct. Pearson product moment correlation coefficients showed no significant effect of age or education on any of the T-Scores and there were no significant gender differences (all $ps > .05$). As shown in the Appendix, there were no significant differences on Digit Symbol T-scores or Symbol Search T-scores by site (Arizona or California) or cohort (Cohort 1 and Cohort 2).

Calculation of the PSI

Table 8 shows the equations used to calculate age-adjusted PSI scores (based on age-adjusted Standard Scores for the Digit Symbol and Symbol Search; see Table 6) and fully demographically-adjusted PSI T-scores (i.e., adjusted for age, education and gender). The age-adjusted PSI and PSI T-scores were normally distributed and had a mean of 100 and SD of 15. Pearson product moment correlation coefficients showed no significant effect of age on the age-adjusted PSI scores ($p = .97$) or PSI T-scores ($p = .99$), and no effect of education on PSI T-Scores ($p = .99$). There were no significant gender differences on PSI T-scores based on an independent sample t-test ($p = .99$). There were also no significant site or cohort differences on PSI T-scores (see Appendix).

Application of existing norms for NHW and NHBAA on the current cohort of Spanish-speakers

As Figure 1 demonstrates, the English language NHW norms resulted in slightly but significant overestimation of impairment rates on both processing subtests: Digit Symbol (20%), $p = 0.008$, and Symbol Search (19%), $p = 0.03$. In contrast, utilization of the norms for English language NHBAA norms yielded impairment rates similar to those using the current NP-NUMBRS norms (*ps* > .05).

Discussion

The current NP-NUMBRS study developed and examined demographically-adjusted normative data for the Spanish language versions of the WAIS-III Digit Symbol Coding and Symbol Search subtests in a sample of 203 U.S.-dwelling Spanish-speaking adults living in the US/Mexico border region. Consistent with prior research, the current results revealed significant demographic effects of age and education on the Digit Symbol Coding and Symbol Search raw scores (Heaton et al.,1996; Heaton et al., 2003; Norman et al., 2000; Tulsky et al., 2003). Following application of the new NP-NUMBRS norms, which are adjusted for age, education, and gender, there were no demographic effects for the adjusted T-scores of either subtest, or of their combined score into a Processing Speed Index. In addition, the rates of neurocognitive impairment derived from previously published norms for English-speaking non-Hispanic white adults (Heaton et al., 2003) overestimated impairment rates on both the Digit Symbol Coding and Symbol Search subtests. In contrast, application of the newly developed NP-NUMBRS norms for Spanish-speakers approximated expected impairment rates for both subtests. Of note, while it is important to avoid overestimating impairment, it is also important to be cognizant that normative adjustments can also underestimate impairment as well. Though this latter issue was not observed in the current study, this is also merits consideration when assessing the clinical utility of normative adjustments.

Although processing speed tests, such as the WAIS-III Digit Symbol Coding and Symbol Search subtests, are sometimes considered “culture-free” due to their designation as nonverbal measures (Cole, 1996), the current study suggests that this is not the case. Consistent with prior research (Duggan et al., 2018; Funes et al., 2016; Rivera Mindt et al., 2010) the current findings suggest that application of population-specific normative data improves the diagnostic utility of these measures. Further bolstering this repeated finding, the current results also revealed that Black/African-American norms resulted in expected impairment rates in this Spanish-speaking sample. This points to the fact that factors driving these processing speed performance differences are unlikely to be purely language related and are also related to other sociocultural factors (e.g., quality of education, test-taking wiseness, socioeconomic status; Rivera-Mindt, Byrd, Saez, & Manly, 2010; Saez et al., 2014). Additionally, a bilingual advantage was found in this study sample across all tests of processing speed, with small to medium effect sizes (Cohen's $d = 0.32$ to 0.55). For additional information regarding differences between monolingual and bilingual English and Spanish-speakers in this sample, refer to the Suarez et al. (in press) paper included in this special issue.

Accurate measurement of processing speed impairments is critical given that such deficits are among the most sensitive indicators of brain damage, and implicated in numerous neurocognitive disorders (e.g., HIV, Parkinson's, traumatic brain injury). Thus, the current NP-NUMBRS norms for the WAIS-III processing speed tests offer an important tool for improving the assessment and diagnosis for a particularly important given population that U.S. Latinas/os suffer significant disparities in brain health (i.e., Alzheimer's Dementia, HIV-associated Neurocognitive Disorder, etc.; Babulal et al., 2019; Prejean et al., 2011).

The current study has some key strengths and limitations that merit consideration. With regard to study strengths, to our knowledge this is the first study to provide demographically-adjusted normative data for a well-characterized sample of US-dwelling Spanish-speakers living in the U.S./Mexico border region on these tests, in the context of a larger norming project that includes a comprehensive neuropsychological test battery. This is a significant contribution to the field considering that Latinas/os of Mexican origin comprise the largest proportion of Latinas/os in the U.S. (US Census Bureau, 2018). To that end, the current normative data is poised to enhance both research and clinical care for this population. With regard to study limitations, the generalizability of the current findings may be limited as this study was carried out in California and Arizona, which only accounts for approximately 50% of the border region (by state) and may not generalize to other Spanish-speaking populations. The fact that upper age limit of this sample was 60 years old is an additional limitation. Further, numerous sociocultural variables (e.g., age of second language learned, nation of origin, time in U.S., acculturation), were not analyzed as a factor in test performance. Additionally, reliability analyses (i.e. test-retest reliability) were not computed due to the cross-sectional nature of the data. Lastly, the clinical utility of the current normative data may vary upon level and quality of education (Artiola i Fortuny et al., 1998).

Future research is needed to investigate the utility of the current norms for other U.S.-dwelling Spanish-speaking subpopulations (e.g., Caribbean, Central American, South American), as well as those from different geographic regions of the U.S. and/or persons of different educational backgrounds. Further, additional normative data for older adults within this population are also needed, as well as more comprehensive assessment of sociocultural characteristics that can impact test performance and clinical utility. Despite this study's limitations, this study represents a crucial step forward in neuropsychology by providing demographically-adjusted normative data for an underrepresented and underserved population that can improve the diagnostic validity of processing speed measures for U.S.-dwelling Spanish-speakers living in the US/Mexico border region.

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Appendix

Appendix.

Comparison of T-Scores on the Digit Symbol and Symbol Search tests, and the Processing Speed Index (PSI) by site and cohort.

Measure	Site			Study cohort		
	Arizona *M* (*SD*)	**California *M* (*SD*)**	***p*[a]**	**Cohort 1 *M* (*SD*)**	**Cohort 2 *M* (*SD*)**	***p*[a]**
Digit Symbol T-scores	48.90 (9.15)	50.53 (10.31)	.27	50.80 (9.97)	48.57 (9.90)	.13
Symbol Search T-scores	49.98 (9.35)	49.97 (10.35)	.99	50.37 (9.98)	49.23 (10.13)	.45
PSI T-scores	99.59 (13.43)	100.15 (15.64)	.79	100.97 (15.09)	98.16 (14.72)	.21

Note. T-Scores developed based on NP-NUMBRS data

[a]Based on independent samples t-tests

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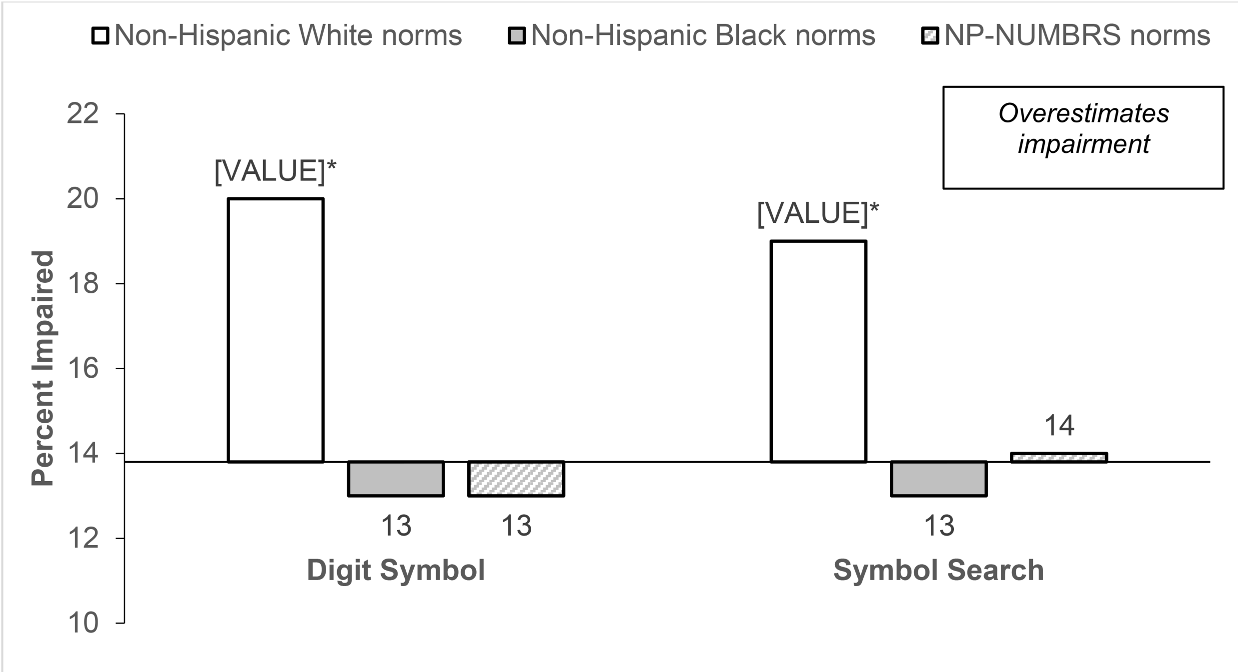

Figure 1.

Caption. Rates of impairment based on published norms for non-Hispanic Whites and NH Blacks, and newly developed norms in processing speed tests. Impairment was defined as T-Score <40. Asterisks denote significant difference based on McNemar's tests compared to currently developed norms.**p*<.05

Table 1.

Educational, Social, and Language Background Characteristics of NP-NUMBRS Participants with Processing Speed Data (*N* = 203)

Characteristics	Descriptives	
	***M*(*SD*), %**	***n***
Educational Background		
Years of education in country of origin	8.51 (4.81)	185
Years of education in the U.S.	2.51 (4.83)	185
Proportion of education by country	--	185
More years of education in country of origin	85.41%	158
More years of education in the U.S.	13.51%	25
Equal number of years of education in both countries	1.08%	2
Type of school attended[a]	--	193
Large	55.96%	108
Regular	38.86%	75
Small	5.18%	10
Number of students in the class	--	197
Less than 21	17.26%	34
21 to 30	36.04%	71
31 to 40	22.84%	45
40+	23.86%	47
Had to stop attending school to work	--	182
Yes	30.22%	55
Social Background		
Mother's years of education	5.78 (3.81)	129
Father's years of education	6.91 (5.19)	119
Years lived in country of origin	26.81 (12.55)	195
Years living in the U.S.	10.88 (11.25)	195
Childhood SES[b]	--	201
Very poor	5.97%	12
Poor	29.35%	59
Middle class	54.23%	109
Upper class	10.45%	21
Worked as a child	--	198
Yes	51.52%	102
Reason to work	--	102
Help family financially	42.16%	43
Own benefit	57.84%	59
Age started working as a child	12.61 (3.25)	98
Currently Gainfully Employed	--	176
Yes	67.61%	119
Language		

Characteristics	Descriptives	
	***M*(*SD*), %**	***n***
First Language	--	200
Spanish	98.50%	197
English	0.50%	1
Both	1.00%	2
Current Language Use Rating[c]		
Radio or TV	2.36 (1.03)	201
Reading	2.21 (1.17)	201
Math	1.52 (1.03)	199
Praying	1.27 (0.76)	193
With family	1.55 (0.89)	196
Performance-based language fluency	--	161
Spanish dominant	63.35%	102
English dominant	0.00%	0
Bilingual	36.65%	59

Notes. M: mean; *SD*: standard deviation; SES: socioeconomic status

[a]Type of school attended: 'large' refers to large school that had many classrooms and room to play); 'regular' refers to a school of regular size that had at least one classroom per grade and room to play; and small school refers to a small school with less than one classroom per grade.

[b]Childhood SES was assessed by the following question and response options: "As a child, your family was: (1) Very Poor; (2) Poor; (3) Middle Class); (4) Upper Class".

[c]Ratings for each activity ranged from 1 "Always in Spanish" to 5 "Always in English", with 3 being "similarly in English and Spanish").

Table 2.

Demographic characteristics of the normative sample stratified by years of education (*N* = 203)

	≤ 6 (*n* = 47)	**7–10 (*n* = 42)**	**11–12 (*n* = 51)**	**≥13 (*n* = 63)**
Age (years), *M* (*SD*)	40.93 (9.91)	38.40 (9.35)	35.63 (10.62)	38.10 (10.83)
Education (years), *M* (*SD*)	4.64 (1.62)	8.64 (0.91)	11.82 (0.39)	15.89 (1.71)
% Female	59.6%	55.8%	66.7%	54.0%

M = mean; *SD* = standard deviation.

Table 3.

Mean, standard deviation (SD), and range of the Digit Symbol and Symbol Search subtests

	Mean (*SD*)	**Range**
Digit Symbol Total Score (*n* = 201)	65.98 (18.62)	21 – 109
Symbol Search Total Score (*n* = 200)	27.69 (8.91)	2 – 48

Table 4.

Association between raw scores and demographic characteristics

	Age[a]	Education[a]	Gender		
			Male (*n*=83)	**Female (*n*=120)**	**P-value[b]**
Digit Symbol Total Score	−0.41 ***	0.62 ***	63.45 (17.88)	67.72 (18.99)	.11
Symbol Search Total Score	−0.36 ***	0.63 ***	27.77 (9.28)	27.63 (8.68)	.91

Note. Based on results from Spearman ρ^a and Wilcoxon rank-sum tests[b].

* p<.05

** p<.01

*** p<.001

Table 5.

Raw-to-scale score conversions

Scaled	Digit Symbol Total Raw Score	Symbol Search Total Raw Score
19	129 – 133	59 – 60
18	106 – 128	49 – 58
17	100 – 105	46 – 48
16	96 – 99	44 – 45
15	93 – 95	41 – 43
14	89 – 92	37 – 40
13	85 – 88	35 – 36
12	76 – 84	33 – 34
11	70 – 75	30 – 32
10	64 – 69	28 – 29
9	57 – 63	25 – 27
8	52 – 56	21 – 24
7	45 – 51	18 – 20
6	38 – 44	14 – 17
5	28 – 37	10 – 13
4	23 – 27	5 – 9
3	17 – 22	3 – 4
2	2 – 16	−49 – 2
1	0 – 1	−60 – −50

Table 6.

Calculation of Age-adjusted Standard Scores for Symbol Search and Digit Symbol

Measure	Equation
Digit Symbol Total Correct Age-adjusted Standard Scores	$15 \times \left(\frac{SS\ Digit\ Symbol\ Total\ Correct - (14.57117 - 11.97140\ *\ \frac{age}{100})}{2.71497} \right) + 100$
Symbol Search Total Correct Age-adjusted Standard Scores	$15 \times \left(\frac{SS\ Symbol\ Search\ Total\ Correct - (13.99737 - 10.48016\ *\ \frac{age}{100}}{2.79611} \right) + 100$

Note. These formulas should be applied to age range of 19–60 years. Using values outside this range might result in extrapolation errors. SS: Scale Score (from Table 4); Age: years of age.

Table 7.

T-Score equations for Digit Symbol Total Score and Symbol Search Total Score

Measure	Equation
Digit Symbol Total Correct T-Score	$10 \times \Bigg(\frac{SS\ Digit\ Symbol\ Total\ Correct - (8.64294 - 9.65537 * \frac{age}{100} + 5.01083 * \left(\frac{edu+1}{10}\right)^2 - 4.6883 * log\left(\frac{edu+1}{10}\right) * \left(\frac{edu+1}{10}\right)^2 - 0.84033 * ge}{1.94673}$
Symbol Search Total Correct T-Score	$10 \times \left(\frac{SS\ Symbol\ Search\ Total\ Correct - (8.65906 - 8.05751 * \frac{age}{100} + 6.17828 * \left(\frac{edu+1}{10}\right)^2 - 2.31936 * \left(\frac{edu+1}{10}\right)^3 + 0.06976 * gender)}{2.12556} \right) + 50$

Note. These formulas should be applied to education level ranges from 0–20 and age 19–60. Using values outside these ranges might result in extrapolation errors. SS: Scale Score (from Table 4); Gender: Male=1; Female=0; Edu: years of education; Age: years of age

Table 8.

Calculation of the Processing Speed Index (PSI)

Measure	Equation
Age-adjusted PSI	$15 \times \left(\frac{[Age - adjusted\ Std.Scr.\ \ Digit\ Symbol\ Total\ Correct + Age - adjusted\ SS\ Symbol\ Search\ Total\ Correct] - 199.9639}{27.53168}\right) + 100$
PSI T-Score	$15 \times \left(\frac{Age - corrected\ PSI - \left(69.149897 + 14.324006 * \frac{age}{100} + 37.586054 * \left(\frac{edu + 1}{10}\right)^2 - 14.247762 * \left(\frac{edu + 1}{10}\right)^3 - 2.443968 * gender\right)}{10.22894}\right) + 100$

Note. These formulas should be applied to education ranges of 0–20 years and age 19–60 years. Using values outside these ranges might result in extrapolation errors. Std.Scr.: Standard Score (based on equations in Table 5); Gender: Male=1; Female=0; Edu: years of education; Age: years of age