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): 324–338. doi:10.1080/13854046.2019.1711199.

Demographically-adjusted norms for the Paced Auditory Serial Addition Test and Letter Number Sequencing Test in Spanish-Speaking Adults: Results from the Neuropsychological Norms for the U.S.-Mexico Border Region in Spanish (NP-NUMBRS) Project

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Abstract

Objective: The Paced Auditory Serial Addition Test (PASAT) and Wechsler Adult Intelligence Scale Letter Number Sequencing subtest (LNS) are two commonly used measures of working memory. Demographic variables (age, education, ethnicity, etc.) can impact performance on these measures, underscoring the need for demographically adjusted norms. We aimed to develop normative data for the PASAT and LNS for Spanish-speaking adults living in the U.S.-Mexico border region as part of a larger normative effort.

Method: Participants were native Spanish-speakers from the Neuropsychological Norms for the U.S. Mexico Border Region in Spanish (NP-NUMBRS) project. Two hundred and forty-nine participants completed the PASAT and 202 participants completed LNS. Ages ranged from 19–60 and education from 0–20 years.

Results: Older age was associated with lower scores on LNS (p<.01) but not PASAT. Lower education was associated with lower scores on both tests (ps<.001). Women obtained lower raw scores than men on PASAT (ps<.003), and there were no significant main effects of gender on LNS raw scores. Raw-to-scaled score conversions were calculated, and fractional polynomial equations were developed to calculate demographically-adjusted T-scores accounting for age, education, and gender. Published norms for English-speaking non-Hispanic Whites substantially overestimated rates of impairment (defined as T-score<40) on both the PASAT and LNS.

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Conclusions: The use of the population-specific normative data may improve detection of working memory dysfunction in U.S. Spanish-speaking adults and contribute to improved diagnostic accuracy and treatment planning in this population. Whether the norms generalize to U.S. Spanish-speakers from other countries remains to be determined.

Keywords

Working memory; Hispanics; Spanish-speakers; Normative Data

Introduction

Working memory can be defined as the temporary storage and manipulation of information. The distinction of these short-term memory skills from long-term memory was first proposed by Donald Broadbent in 1958. Evidence came, in part, from patients such as HM and those with Korsakoff's syndrome who had deficits in long-term storage of information while maintaining a normal immediate memory span (e.g., the ability to repeat a string of numbers forward and backward). Although working memory requires attention, it is more complex than the construct of basic attention, which is a combination of top-down (i.e., effortful endogenous allocation of awareness) and bottom-up (i.e., exogenous redirection of awareness, e.g., by the sudden appearance of an environmental stimulus) processes. Working memory, however, has been theorized to require not only top-down attentional control, but also a visuospatial sketchpad to manipulate visual information, and a phonological loop to manipulate verbal information (Baddeley, 1983). Working memory capacity also involves the ability to maintain an active representation of information in the face of competing information that may capture bottom-up attention (Engle et al., 1999).

Working memory assessment has become an important component of neuropsychological evaluations. It has predictive power in children for academic attainment (Alloway & Alloway 2010), is closely linked to fluid intelligence in adults (i.e., the ability to solve novel problems and adapt to new situations; Engle et al., 1999), and can help differentiate between frontotemporal dementia and dementia of the Alzheimer's type in older adults (Kramer et al. 2003). Working memory deficits are prominent in a variety of clinical populations, including individuals with schizophrenia (Keefe et al., 1995), traumatic brain injury (McDowell, Whyte, & D'Esposito, 1997), attention-deficit/hyperactivity disorder (Hervey et al., 2004, Martinussen & Tannock, 2006), vascular cognitive impairment (Sachdev et al., 2004), Parkinson's disease (Gabrieli et al., 1996, Lee et al., 2010), and HIV (Heaton et al., 2011).

Two commonly used neuropsychological tests that elicit auditory working memory skills are the Paced Auditory Serial Addition Task (PASAT) (Gronwall & Sampson, 1974) and the Letter Number Sequencing (LNS) subtest from the third edition of the Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1997). Several investigations show that demographic variables impact PASAT and LNS performance. PASAT performance has been shown to be significantly related to age, education, and race/ethnicity in adults (Diehr et al., 2003; Ryan, Baird, Mindt, Byrd, Monzones, & Morgello, 2005). Age and education have also been shown to impact LNS performance in adults (Crowe, 2000; Myerson, Emery, White, & Hale, 2010; Ryan, Baird, Mindt, Byrd, Monzones, & Morgello, 2005), and at least one study shows that LNS norms from Spain may underestimate abilities for Spanish-speakers living in the U.S., possibly because the letters “B” and “V” sound similar in Latin American Spanish whereas they are clearly distinct in Spain (Renteria, Tinsley, & Pliskin, 2008). Thus, demographically accurate norms – accounting not only for linguistic status but also country of origin – are essential when assessing cognitive functioning using the PASAT and LNS.

Normative data for LNS in Spanish-speaking populations is available via several versions of the WAIS, which were specifically adopted for Spanish-speakers in Puerto Rico (Wechsler, 2008), Spain (Wechsler, 2001), and Mexico (Wechsler, 2003). Also, the Spanish Multicenter Normative Studies (NEURONORMA Project) produced normative data for adults in Spain aged >49 years (Peña-Casanova et al., 2009) and those aged 18–49 (Tamayo et al., 2012). For pediatric populations, Spanish versions of the fourth and fifth editions of the Wechsler Intelligence Scale for Children were developed for use with Spanish-speaking children in the U.S., with the normative samples including U.S.-dwelling children from diverse regions of origin including Mexico, Central America, Cuba, Puerto Rico, the Dominican Republic, and South America (Wechsler, 2004; Wechsler, 2017). However, the reported norms did not specifically differentiate performance based on country of origin.

Despite the availability of these norms, review of the literature indicates that the only normative LNS data for Spanish-speaking adults living in the U.S. is for Puerto Ricans (as all other adult-focused norms were generated internationally). Similarly, there is a complete lack of normative PASAT data in Spanish-speakers generally, and no available norms for Hispanic/Latino/a/x (hereafter referred to as Hispanics/Latinos) adults living in the U.S. specifically. The current study provides demographic corrections for the PASAT and LNS based on data collected from Spanish-speaking adults living in the U.S.-Mexico border region.

Methods

Participants and procedures

Two hundred and forty-nine participants completed the PASAT and 202 participants completed the WAIS-III LNS as part of a comprehensive neuropsychological battery that was administered as part of a larger normative effort called the Neuropsychological Norms for the U.S.-Mexico Border Region in Spanish (NP-NUMBRS) project. This norming project spanned two cohorts recruited at different time points (Cohort 1 between 1998–2000 and Cohort 2 between 2006–2009) from or near the regions of San Diego, California, and Tucson, Arizona. All participants were native Spanish-speakers with a range of English language proficiency (from Spanish monolingual to balanced bilingual), some of whom were recruited as controls specifically for a normative study, and others as healthy volunteers/normal controls for studies of neurocognitive effects of HIV infection. Bilingualism was primarily determined based on participants’ self-report, though performance-based language fluency measures were also administered to a subset of participants (see Table 2).

Potential participants for both cohorts were screened based on similar inclusion and exclusion criteria using structured interviews. Participants were excluded for any condition or illness that may influence test performance, such as a central nervous system disorder, medical condition, serious psychiatric condition, or peripheral injury. Less serious conditions or disabilities were reviewed on a case-by-case basis by senior investigators. Participants who could not recite the alphabet correctly were excluded from LNS administration. For additional details on study recruitment, participants, and procedures, see Cherner and Marquine et al.[b] (this issue).

Multiple papers in this special issue on the NP-NUMBRS project present demographically-corrected norms for all cognitive domains in this battery. This includes measures of verbal fluency (Marquine et al.[a], this issue), speed of information processing (Rivera Mindt et al.[a], Suárez et al.[a], this issue), executive functioning (Marquine et al.[b], Morlett Paredes et al.[b], Suárez et al.[a], this issue), learning and memory (Díaz-Santos et al., this issue), visuospatial skills (Scott et al., this issue), and fine motor skills (Heaton et al., this issue). For additional information on this NP-NUMBRS project and the state of norms for Spanish-speakers in this U.S.-Mexico border region, see the introduction paper (Cherner et al.[a]) and review paper (Morlett Paredes et al.[a]) in this issue. Finally, a paper by Kamalyan et al. (this issue) begins to address the validity of the current norms for most tests in the NP-NUMBRS battery for detecting central nervous system disorders by applying the norms to test results of Spanish-speaking, U.S.-Mexico border region residents with HIV infection.

LNS was administered in Spanish by a bilingual (Spanish/English) psychometrist, and PASAT was administered in Spanish via audiotape, which was pre-recorded by a native Spanish-speaking psychometrist under the supervision of a bilingual neuropsychologist. Inter-stimulus intervals for each PASAT trial were assembled electronically to maintain fidelity with the English-language recording used in the Heaton et al. (1991, 2004) Expanded Halstead-Reitan Battery norms. Instructions for both measures were back-translated and examined for fidelity with the English versions using procedures described in previous studies (Artiola I Fortuny et al., 1999; Cherner et al., 2007).

During administration of PASAT, individuals hear a string of digits via audio recording, and they are required to respond by stating the sum of the previous 2 digits heard. Each digit must be temporarily stored while mentally adding it to the prior, and then the digit in temporary storage is updated once the next is heard, and it is summed to the previous, and so forth. For example:

Audiotape:	2	–	3	–	1	–	6	
Target Response:				5	–	4	–	7

Stimulus presentation includes four series of 50 digits each. With each subsequent sequence, the inter-stimulus intervals are reduced, making each series more challenging than the previous.

During administration of LNS, individuals listen to a string of numbers and letters read aloud by an examiner. They are then required to respond by repeating the numbers, in ascending order, followed by the letters in alphabetical order. Like in the PASAT, information is temporarily stored and manipulated to arrive at an answer. For example:

Examiner:	3	–	C	–	2	–	A	–	7
Target Response:	2	–	3	–	7	–	A	–	C

Please see the Appendix for the test administration instructions in Spanish used for the PASAT. The administration instructions for LNS can be found in the manual for the WAIS-III in Spanish from Mexico (Wechsler, 2003).

Statistical analyses

Shapiro-Wilk tests were used to examine the distribution of raw scores. Pearson product moment correlation coefficients (or Spearman ρ) were used to examine the univariate associations between demographic characteristics (age, education, and gender) and raw test scores. Separate linear regression models were used to examine the interactive effects of demographic variables on raw test scores (i.e., age X education, age X gender, education X gender). Education was included as a continuous variable in all analyses.

After the effects of age, education, and gender on raw test scores were examined, normative scores were calculated by converting raw scores to normalized scaled scores (mean=10, SD=3). Fractional polynomial equations were then developed to calculate demographically-corrected T-scores accounting for age, education, and gender (Royston P & Sauerbrei W, 2009). Please see Cherner and Marquine et al. (this issue) for further details on norming procedures.

Outcome scores included the following:

LNS Total Score: Total number of correct responses across trials (range = 0–21)

PASAT-50 Total Correct: Total number of correct responses from audio series 1 (range = 0–50)

PASAT-200 Total Correct: Total number of correct responses from audio series 1–4 (range = 0–200)

Shapiro-Wilk tests were used to examine the distribution of the resulting T-scores. Pearson product moment correlation coefficients for age and education, and an independent sample t-test for gender, were used to examine the association between T-scores and demographic variables. We also compared the resulting T-scores by cohort and site via independent sample t-tests.

Lastly, we used existing published norms for English-speaking non-Hispanic (NH) Whites and Blacks (Heaton et al., 2004) to calculate T-scores for the present sample, and we computed rates of impairment using both sets of norms. Impairment was defined as T-score less than 40 (i.e., one standard deviation below the mean). Because of the normalized distribution of T-scores, by definition, it is expected that approximately 16% of the sample should fall in the impaired range. McNemar's tests were used to compare the rates of impairment found when applying our newly-developed Spanish-speaking norms and published norms for English-speaking NH Whites and Blacks (Heaton et al., 2004).

Results

Demographic characteristics of the norming sample

Demographic characteristics of the norming sample are presented in Table 1. Age ranged from 19 to 60 years, education ranged from 0 to 20 years, and slightly over half of the sample was female. There were no significant differences for age or gender between participants who completed both tests and those who completed only the PASAT (p=0.87 and p=0.98, respectively). Participants who completed both tests had, on average, lower education (10.2 vs 12.3 years, p=0.002).

A subset of participants completed self-report questionnaires aimed at collecting information on educational, sociocultural and language use background. These characteristics are included in Table 2 and are stratified by test. Unfortunately, not all participants had data available on these measures, so the table data is limited. Due to the complexity of the interactions among the educational and social characteristics with both corrected and uncorrected scores, the significant associations between these background characteristics with various cognitive domains in this NP-NUMBRS issue will be described in a separate, upcoming paper.

Raw score to scale score conversions

Table 3 shows descriptive characteristics of raw scores on LNS and PASAT. Results from Shapiro-Wilk tests indicated LNS and PASAT-50 raw scores were not normally distributed, while PASAT-200 raw scores were normally distributed. Table 4 shows the association of raw scores with demographic variables based on Pearson product moment correlation coefficients or Spearman ρ (for age and education) and independent sample t-tests or Wilcoxon rank-sum tests (for gender).

There were small but significant effects of age on LNS such that older age was associated with lower raw scores (p<.01). There were no significant effects of age on PASAT-50 or PASAT-200 raw scores. There were large effects of education such that lower education was associated with lower raw scores on all three measures (ps<.001). Women obtained lower raw scores than men on the PASAT (ps<.003), and there were no significant main effects of gender on LNS raw scores. There were no significant two-way interaction effects of demographic characteristics on LNS or PASAT raw scores.

Table 5 shows the raw-to-scale score conversions for the LNS and PASAT scores.

T-score equations

Table 6 shows the T-score equations used to compute individual T-scores. As expected, the resulting T-scores had a mean of 50 and a standard deviation (SD) of 10. T-scores ranged from 23 to 81 for LNS, from 24 to 74 for the PASAT-50, and from 25 to 77 for the PASAT-200. For the subset of participants who had data on all outcome measures (n=187), all T-scores had a mean of 50 and an SD of 10. 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. There were no significant non-linear effects of any demographic variables.

Group comparisons

Table 7 shows descriptive statistics of T-scores by site (Arizona and California) and cohort (Cohorts 1 and 2). Independent sample t-tests showed no significant differences between Cohorts 1 and 2 for T-scores on the PASAT-50 (p=.21) or PASAT-200 (p=.19). When the overall sample was stratified by location of recruitment, similar analyses revealed non-significant findings for both the PASAT-50 (p=.96) and LNS (p=.40). There was a statistically significant difference for LNS when comparing Cohorts based on time, such that scores were lower in Cohort 2 (N=71; M=47.59; SD=11.27) compared to Cohort 1 (N=183; M=51.32; SD=9.03), but with a small effect size (p=.01; Cohen's d=−0.38). There were no significant differences by site (Arizona and California) for T-scores for LNS (p=.40), PASAT-50 (p=.96), or PASAT-200 (p=.63).

Applications of existing norms

As shown in Figure 1, utilizing norms based on English-speaking NH Whites substantially overestimated rates of impairment on both LNS (34%) and PASAT (50-item = 30%, 200-item = 35%). By contrast, norms for English-speaking NH Blacks approximated the expected rate of impairment on PASAT-200 (18%) and PASAT-50 (13%). Rates of impairment on LNS were essentially equivalent using norms for English-speaking NH Blacks (16%).

Discussion

Findings from the current study corroborate prior research showing that when norms for NH white adults are applied to Spanish-speaking adults, impairment rates are inflated. This was true for both LNS and the PASAT in the current study and has been shown to be true using other instruments in prior research (Cherner et al., 2007). This has significant implications in both clinical and research settings, as individuals may erroneously be classified as having working memory impairments when, in fact, their scores reflect demographic differences or the potential for cultural/linguistic test biases. In addition to the influences of ethnicity, other demographic calculations showed that greater age was associated with lower LNS raw scores, fewer years of education was associated with lower scores on both LNS and PASAT, and male gender was associated with higher PASAT scores. Examination of impairment rates suggest that our Hispanic/Latino norms may better account for the effects of age, education, and gender in this population. For information regarding the clinical applicability of these norms and cognitive impairment in a population of individuals living with HIV in the U.S., see the paper by Kamalyan and colleagues (this issue).

To our knowledge, this is the first study to provide normative data for LNS and PASAT for Spanish-speaking U.S.-dwelling adults. Previous investigations have shown that demographic variables impact PASAT and LNS performance in adults (Crowe, 2000; Diehr et al., 2003; Myerson, Emery, White, & Hale, 2010; Ryan, Baird, Mindt, Byrd, Monzones, & Morgello, 2005), though there is a complete lack of normative PASAT data in Spanish-speakers generally, and no available norms for either test for Hispanics/Latinos living in the U.S. specifically.

Accurate assessment of neurocognitive functioning generally, and working memory specifically, is imperative in determining normal expectations and criteria for classifying disease-related impairment. As was demonstrated in the current study, the application of norms from a different population (i.e., NH Whites) can make Spanish-speakers appear more impaired than they are. In order to ensure the competent delivery of culturally and linguistically appropriate neuropsychological services, as well as to ensure the reliability of research results in ethnically diverse populations, the use of the population-specific normative data is often critical. Doing so may improve detection of working memory dysfunction in Spanish-speaking adults living in the U.S. and contribute to improved diagnostic accuracy and treatment planning in this population.

Although this study successfully generated normative data for Spanish-speaking individuals living in the U.S., it is not without significant limitations. First, all study participants resided in the U.S.-Mexico border regions of California and Arizona, and almost all were individuals of Mexican heritage (see Cherner and Marquine, et al., this issue). Whereas California has the largest population of Hispanic/Latinos in the U.S., and the majority of all Hispanic/Latinos in the U.S. originate from Mexico (U.S. Census Bureau, 2017), this sample does not reflect the heterogeneity of Hispanic/Latinos living in other regions of the U.S., and it will be important for future work to examine the generalizability of the current norms to other segments of the U.S. Hispanic/Latino population. Second, the age range for this sample did not include adults over age 60. Consequently, the data cannot be applied to older adults, thereby limiting the clinical applications in this neurologically vulnerable age group. Third, the sample characteristics for potentially relevant variables that may influence test performance, such as acculturation, duration of U.S. residency, degree of bilingualism, location of education, language of instruction, etc., were not consistently recorded here (see Cherner and Marquine et al.[b], this issue). Although substantial sociodemographic details were collected from a subset of participants, we did not investigate the potential impact of these factors on LNS or PASAT performance in the present paper. Related to this, considering the impact of bilingualism on cognition (Adesope, Lavin, Thompson, & Ungerleider, 2010; Bialystock, 2017), a paper in this special issue investigates the association between bilingualism and performance on the entire NP-NUMBRS test battery (Suarez[b] et al., this issue). Future studies should carefully record these details in a standard fashion to examine the effects of such characteristics on neurocognitive test performance.

Finally, the data on which the current norms are based were collected 10 to 20 years ago. Since we do not have more current data for Spanish-speakers on these tests, we cannot examine whether there may be a Flynn or cohort effect when compared with individuals from contemporary cohorts. However, when significant differences between the current cohorts (tested 10 years apart) were investigated in another paper in this issue (Cherner & Marquine et al.[b]), only a few differences were found. Of particular relevance for this paper, only the LNS scores differed, such that scores were lower in Cohort 2 compared to Cohort 1. Notably, however, the effect size was small, and these findings are actually antithetical to the Flynn effect, which would anticipate inflated scores over time (Flynn, 1984). Nevertheless, it is possible that inherent differences between the original English-speaker norms and our Spanish-speaker norms might be due to the Flynn effect or other factors. Due to the length of time since all of these normative studies ended, revalidation of these norms with more contemporary data would be needed to clarify or definitively rule out a generational effect.

Clinicians and researchers are asked to consider these limitations on a case-by-case basis when deciding to apply the resulting norms. For more information on the NP-NUMBRS norming project and next steps, see the paper by Rivera Mindt et al.[b] (this issue). Also, for the interested reader, a user-friendly digital calculator will be available for clinicians to generate T-scores for LNS and the PASAT to implement in the assessment of working memory based on the current new norms for this particular population.

Acknowledgements

All authors attest that there are no conflicts of interest with this work. This manuscript was supported by NIH grants P30MH62512, R01MH57266, K23MH105297, P30AG059299, the UCSD Hispanic Center of Excellence (HRSA D34HP31027) and T32 MH019934.

Appendix

Paced Auditory Serial Addition Test Instructions

Instructions to the participant:

"En una grabación escuchará la voz de un hombre que dirá números del 1 y 9. Usted tendrá que sumar el primer número al segundo número que escuche y decirme la suma en voz alta. Después tendrá que sumar el segundo número al tercer número que escuche y decirme la suma, en voz alta de nuevo, y así sucesivamente. Hagamos algunos ejemplos."

Give all 3 examples with paper and pencil:

9 7 5 (Responses: 16, 12)

8 6 8 (Responses: 14, 14)

3 9 3 (Responses: 12, 12)

Then say:

"La grabación avanza rápidamente, así que asegúrese de dar su respuesta antes de escuchar el siguiente número. Si pierde la suma, trate de reanudarla lo más pronto posible."

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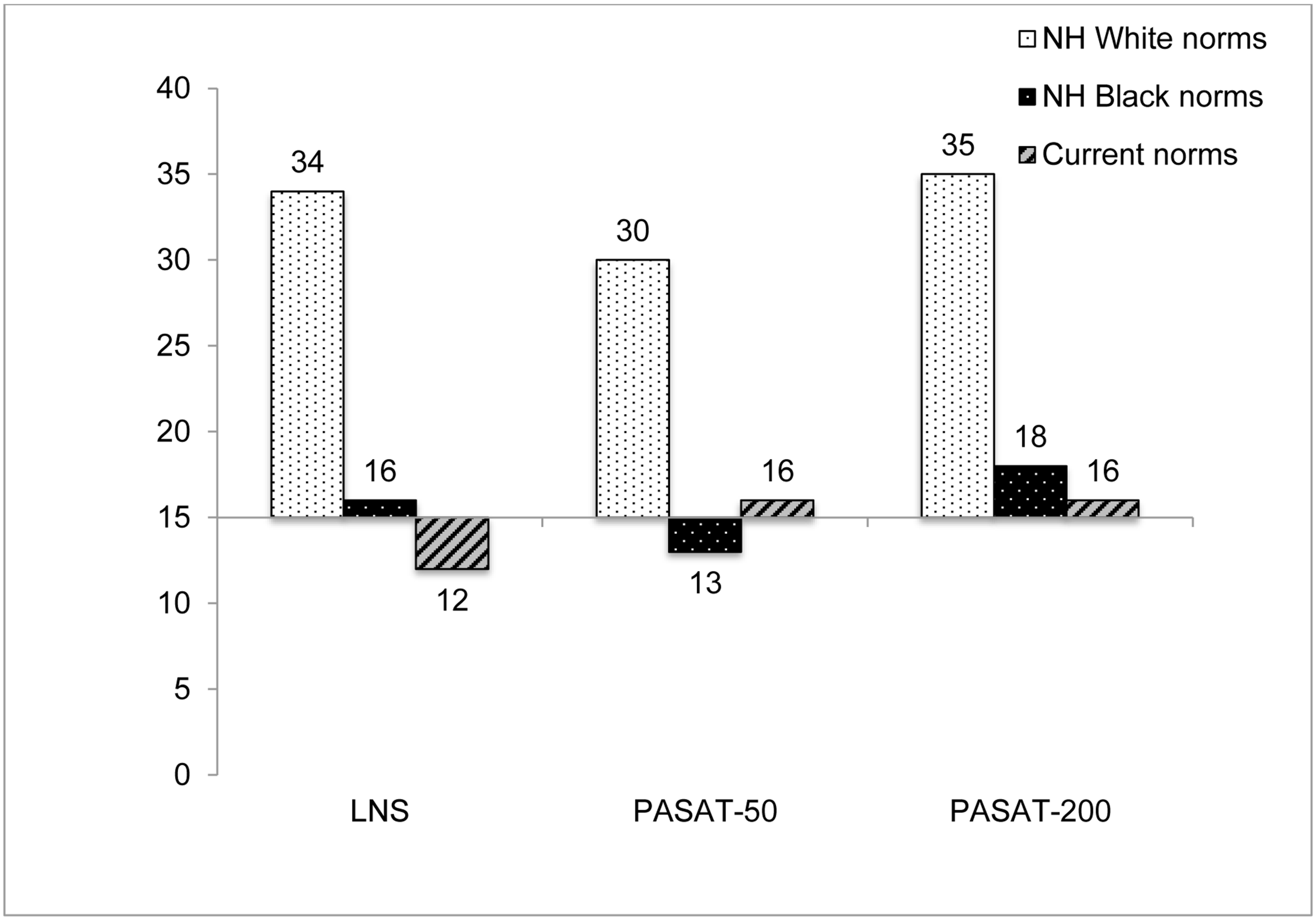

Figure 1.

Comparing rates of impairment utilizing existing published norms vs. current study norms. *Note*. Impairment defined as T-score < 40. Threshold for over- or underestimating impairment is set at 16%; NH=non-Hispanic; LNS = Letter-Number Sequencing; PASAT = Paced Auditory Serial Addition Test.

Table 1.

Demographic characteristics of the normative sample for LNS and PASAT.

	LNS (*N*=202)	PASAT (*N*=249)
Age (years)		
Mean (*SD*)	38.1 (10.3)	37.3 (10.2)
Range	19–60	19–60
Education (years)		
Mean (*SD*)	10.8 (4.4)	10.7 (4.3)
Range	0–20	0–20
% Female	58.9%	58.6%

Note. SD = standard deviation; LNS = Letter Number Sequencing; PASAT = Paced Auditory Serial Addition Test.

Table 2.

Educational, Social, and Language Background Characteristics of NP-NUMBRS Participants with Data on Tests of WAIS-III LNS (*N*=202) and PASAT (*N*=249)

Characteristics	LNS *M* (*SD*), %	*n*	PASAT *M* (*SD*), %	*n*
Educational Background				
Years of education in country of origin	8.53 (4.82)	184	8.54 (4.78)	222
Years of education in the U.S.	2.53 (4.84)	184	2.51 (4.72)	222
Proportion of education by country	--	184	--	222
More years of education in country of origin	85.33%	157	84.69%	188
More years of education in the U.S.	13.59%	25	14.41%	32
Equal number of years of education in both countries	1.09%	2	0.90%	2
Type of school attended[a]	--	192	--	239
Large	56.25%	108	55.23%	132
Regular	38.54%	74	40.17%	96
Small	5.21%	10	4.60%	11
Number of students in the class	--	196	--	242
Less than 21	17.35%	34	14.46%	35
21 to 30	36.22%	71	40.08%	97
31 to 40	22.96%	45	24.38%	59
40+	23.47%	46	21.07%	51
Had to stop attending school to work	--	181	--	219
Yes	30.39%	55	29.22%	64
Social Background				
Mother's years of education	5.77 (3.83)	128	5.76 (3.66)	179
Father's years of education	6.92 (5.22)	118	6.80 (5.07)	162
Years lived in country of origin	26.84 (12.57)	194	26.65 (12.49)	240
Years living in the U.S.	10.76 (11.15)	194	10.48 (10.69)	240
Childhood SES[b]	--	200	--	246
Very poor	6.00%	12	5.69%	14
Poor	29.50%	59	27.24%	67
Middle class	54.00%	108	58.54%	144
Upper class	10.50%	21	8.54%	21
Worked as a child	--	197	--	244
Yes	51.78%	102	53.28%	130
Reason to work	--	100	--	129
Help family financially	42.00%	42	38.76%	50
Own benefit	58.00%	58	61.24%	79
Age started working as a child	12.61 (3.25)	98	13.05 (3.12)	126
Currently Gainfully Employed	--	175	--	220
Yes	68.00%	119	68.64%	151
Language				
First Language	--	199	--	245

Characteristics	**LNS *M* (*SD*), %**	***n***	**PASAT *M* (*SD*), %**	***n***
Spanish	98.49%	196	98.78%	242
English	0.50%	1	0.41%	1
Both	1.01%	2	0.82%	2
Current Language Use Rating[c]	--			
Radio or TV	2.36 (1.03)	200	2.38 (1.03)	246
Reading	2.22 (1.17)	200	2.23 (1.17)	246
Math	1.52 (1.04)	198	1.54 (1.06)	244
Praying	1.28 (0.76)	192	1.26 (0.73)	235
With family	1.55 (0.89)	195	1.54 (0.88)	241
Performance-based language fluency	--	160	--	200
Spanish dominant	63.13%	101	62.50%	125
English dominant	0.00%	0	0.00%	0
Bilingual	36.88%	59	37.50%	75

Note. *M* = mean; *SD* = standard deviation.

[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”).

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Table 3.

Mean, standard deviation, and range of the LNS and PASAT raw scores

	Mean (SD)	Range
LNS	8.71 (2.88)	3 – 19
PASAT-50	32.14 (11.38)	7 – 49
PASAT-200	101.84 (33.45)	23 – 187

Note. SD = standard deviation; LNS = Letter Number Sequencing; PASAT = Paced Auditory Serial Addition Test.

Table 4.

Univariable association between raw scores and demographic characteristics

	N	Age[a]	Education[a]	Sex[b]		
		r^2	r^2	Male Mean (SD)	Female Mean (SD)	*p*
LNS	202	−0.19**	0.64***	8.92 (3.21)	8.57 (2.64)	NS
PASAT-50	249	−0.06	0.39***	34.54 (11.19)	30.45 (11.24)	.003
PASAT-200	238	−0.04	0.41***	111.86 (36.32)	94.57 (29.26)	<.001

Note. Based on results from Pearson product moment correlation coefficients or Spearman ρ

[a] and independent sample tests or Wilcoxon rank-sum tests

[b] ; SD = standard deviation; NS = not significant; LNS = Letter Number Sequencing; PASAT = Paced Auditory Serial Addition Test.

* p<.05,

** p<.01,

*** p<.001

Table 5.

Raw-to-scale score conversions

Scaled	LNS Total Score	PASAT-50	PASAT-200
19	21	50	196–200
18	18 – 20	--	183–195
17	16 – 17	--	166–182
16	14 – 15	49	158–165
15	13	48	151–157
14	12	46–47	142–150
13	--	44–45	134–141
12	11	41–43	122–133
11	10	36–40	108–121
10	9	31–35	95–107
9	8	26–30	83–94
8	7	22–25	73–82
7	6	18–21	62–72
6	5	15–17	51–61
5	4	10–14	40–50
4	--	9	33–39
3	3	8	28–32
2	1–2	3–7	9–27
1	0	0–2	0–8

Note. LNS = Letter Number Sequencing; PASAT = Paced Auditory Serial Addition Test.

Table 6.

T-Score equations

Measure	Equation
LNS	$10 \times \left(\frac{SS\ LN\ Seq - (6.59395 - 4.84684 * \frac{age}{100} + 4.22706 * \frac{(edu + 1)}{10} + 0.21835 * gender)}{2.32523} \right) + 50$
PASAT-50	$10 \times \left(\frac{SS\ PASAT50 - (6.51777 - 0.82745 * \frac{age}{100} + 2.89908 * \frac{(edu + 1)}{10} + 0.83867 * gender)}{2.66095} \right) + 50$
PASAT-200	$10 \times \left(\frac{SS\ PASAT200 - \left(6.2218 + 0.01359 * \frac{age}{100} + 2.7592 * \frac{(edu + 1)}{10} + 1.39324 * gender\right)}{2.64909} \right) + 50$

Note. LNS = Letter Number Sequencing; PASAT = Paced Auditory Serial Addition Test; These formulas should be applied to education level ranges from 0–20 and age ranges from 19–60. Using values outside these ranges might result in extrapolation errors.

Gender: Female=0; Male=1

Edu=years of education

Age=years of age

Table 7.

T-scores by study site and cohort on Letter Number Sequencing, PASAT-50 and PASAT-200 based on newly developed norms

	Study Site		Study Cohort	
	Arizona	**California**	**Cohort 1**	**Cohort 2**
Letter-Number Sequencing	50.85 (9.09)	49.64 (10.40)	51.32 (9.03) *	47.59 (11.27) *
PASAT-50	49.97 (10.93)	50.03 (9.35)	50.49 (9.97)	48.69 (10.03)
PASAT-200	50.58 (10.87)	49.78 (9.47)	50.70 (10.15)	48.62 (9.40)

Note.

* p=.01; Cohen's d=−0.38. All other comparisons are non-significant.