Published in final edited form as:
Clin Neuropsychol. 2017 May ; 31(4): 783–797. doi:10.1080/13854046.2016.1276216.

Performance of Hispanics and Non-Hispanic Whites on the NIH Toolbox Cognition Battery: The Roles of Ethnicity and Language Backgrounds

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Abstract

Objective—This study examined the influence of Hispanic ethnicity and language/cultural background on performance on the NIH Toolbox Cognition Battery (NIHTB-CB).

Method—Participants included healthy, primarily English-speaking Hispanic (n=93; Hispanic-English), primarily Spanish-speaking Hispanic (n=93; Hispanic-Spanish), and English speaking Non-Hispanic White (n=93; NH White) adults matched on age, sex, and education levels. All participants were in the NIH Toolbox national norming project and completed the Fluid and Crystallized components of the NIHTB-CB. T-scores (demographically-unadjusted) were developed based on the current sample and were used in analyses.

Results—Spanish-speaking Hispanics performed worse than English-speaking Hispanics and NH Whites on demographically-unadjusted NIHTB-CB Fluid Composite scores ($ps<.01$). Results on individual measures comprising the Fluid Composite showed significant group differences on tests of executive inhibitory control ($p=.001$), processing speed ($p=.003$), and working memory ($p<.001$), but not on tests of cognitive flexibility or episodic memory. Test performances were associated with language/cultural backgrounds in the Hispanic-Spanish group: better vocabularies and reading were predicted by being born outside the U.S., having Spanish as a first language, attending school outside the U.S., and speaking more Spanish at home. However, many of these same background factors were associated with worse Fluid Composites within the Hispanic-Spanish group.

Conclusions—On tests of Fluid cognition, the Hispanic-Spanish group performed the poorest of all groups. Socio-demographic and linguistic factors were associated with those differences. These findings highlight the importance of considering language/cultural backgrounds when interpreting

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neuropsychological test performances. Importantly, after applying previously published NIHTB-CB norms with demographic corrections, these language/ethnic group differences are eliminated.

Keywords

Acculturation; Cultural Aspects; Cognition; Toolbox; Language

Introduction

Hispanics are the largest ethnic minority group in the United States (U.S.), accounting for 16.3% of the total U.S. population (Ennis et al., 2011). They are also one of the fastest growing ethnic groups with a 43% increase between 2000 and 2010, accounting for over half of the total increase in the U.S. population (Ennis, Rios-Vargas, & Albert, 2011). With the continuation of this trend, the demographic profile of the U.S. is estimated to change radically by 2050, with Hispanics accounting for up to a third of the population (Passel & Cohn, 2008). Importantly, Hispanics are a very heterogeneous group, comprising multiple national origins, races, patterns of immigration, educational backgrounds, and languages, which contribute to the complexities and difficulties with generalization when studying this population. Yet, there are also salient cultural aspects that characterize a Hispanic collective experience (Zayas & Solari, 1994; Sabogal et al., 1987), which might have important implications for neuropsychological assessment.

The rapid change in demographics of the U.S. population has made it necessary to understand whether Hispanics, as a group, perform differently on neuropsychological tests from other racial/ethnic groups. Considering the heterogeneity within Hispanics, it is also important to determine the cultural and other background factors (i.e. place of birth, length of residence, language use) that may influence performance on neuropsychological evaluations. Despite this need, relatively few studies address the impact of Hispanic ethnicity and related sociocultural factors on neuropsychological assessments (Gasquoine, 2001).

A major aim of neuropsychological testing is to detect acquired brain impairment and changes in functioning from a prior, “premorbid” baseline (Gasquoine, Croyle, Cavazos-Gonzalez, & Sandoval, 2007). Clinical neuropsychological evaluations can have important healthcare consequences, including providing, diagnosis, prognosis, treatment recommendations, and other intervention guidance. It is well established, however, that neuropsychological test performances of persons without known neurological conditions can be influenced by demographic factors such as age, education, gender, and race/ethnicity (Heaton et al., 2004; Gasquoine et al., 2007). Thus, the neuropsychologist must determine the possible impact of non-neurological factors, such as demographic and experiential backgrounds, on the presenting neuropsychological performance (Sbordone & Long, 1996). Normative neuropsychological test standards can account for demographic factors and have proven to be a useful approach to control for demographic influences and facilitate interpretation of possible acquired neurological injury (Gasquoine et al., 2007). In addition, however, other background experiences (e.g. acculturation, bilingualism, and quality of education) may have major additional effects on neuropsychological test performances (Arnold et al., 1994; Gasquoine et al., 2007; Puente & Ardila, 2000; Manly et al., 2004).

Despite the need, there is only scant research examining background factors within U.S. Hispanics and contrasting neuropsychological performances of healthy Hispanics living in the U.S. and other ethnic/racial groups. Most research on U.S. Hispanic neuropsychological performances has examined poorly educated, Spanish-speaking, elderly participants and has lacked comparison groups (i.e. Non-Hispanic Whites) (Gasquoine, 2001; Acevedo et al, 2007). The few studies that have compared Hispanic and Non-Hispanic White performances have focused on specific subgroups (i.e., older or younger individuals) and typically have found that, among neurologically normal individuals, Hispanics perform significantly lower on neuropsychological tests compared to their Non-Hispanic White counterparts (Arnold et al, 1994; LaRue et al., 1999; Mulgrew et al., 1999; Boone et al, 2007). For example, in a study of older adults tested in Spanish and English, Mungas and colleagues (2005) found that Hispanic ethnicity (compared to Non-Hispanic White) was significantly associated with worse performance across all but one subscale (Word List Learning-II) of the Spanish and English Neuropsychological Assessment Scales (SENAS).

Although research aimed at understanding the factors explaining these ethnic differences in neuropsychological performance is relatively limited, it is commonly accepted that performances on psychometric tests can be strongly influenced by the values observed in the specific cultures in which they were developed (Ardila, 2005). In the study of Hispanics living in the U.S., this translates into the need to take degree of acculturation into account when interpreting results of neuropsychological examinations (Rey, Feldman, Rivas-Vasquez, Levin, & Benton, 1999). Acculturation refers to the process by which people adopt the attitudes, beliefs, values, customs, and behaviors of a new culture; however, the definition and measurement of acculturation varies considerably (Thomson & Hoffman-Goetz, 2009).

While a number of factors reflect acculturation of Hispanics in the U.S. (Coronado et al., 2004; Marin & Gamba, 1996; Marin et al., 1987), our study specifically examined first language learned, degree of language usage, place of birth, and whether or not participants went to school in the US. Length of residence in the U.S. and degree of English and Spanish language usage, have been used as estimates of acculturation (Gasquoine, 2001; Unger et al, 2007). Recognizing that they are highly related, length of residence in the United States and bilingualism both have been found to impact neuropsychological performance (Bialystok et al., 2004; Harris et al., 1995; Artiola i Fortuny et al., 1998). For example, in a study of Spanish-speaking Hispanics from the U.S.-Mexico Borderland area, length of residence in the U.S. positively related to executive functions (Wisconsin Card Sorting Test), but was negatively correlated with Spanish lexical fluency performances (Artiola i Fortuny et al., 1998). Similarly, results from various studies indicate that bilingualism may have negative effects on vocabulary knowledge/language skills, but a positive impact on executive control tasks, working memory, and verbal learning tasks (Prior & Gollan, 2011; Harris et al., 1995; Bialystok et al., 2004). For instance, in a study of verbal fluency in Spanish-English bilinguals and English monolinguals, bilinguals produced fewer correct responses (i.e., semantic, letter, and proper name fluency) than monolinguals (Gollan, Montoya, Werner, 2002). Overall, these findings highlight the important role that culturally-relevant factors, such as acculturation and language use might play in interpreting results of neuropsychological evaluations among Hispanics.

The primary aim of the present study was to investigate potential differences in neuropsychological performance among neurologically healthy Hispanics tested in English (Hispanic-English), Hispanics tested in Spanish (Hispanic-Spanish), and Non-Hispanic Whites tested in English (NH White). In order to do so, we compared performance of otherwise demographically-matched language/ethnic groups of participants in the NIH Toolbox Cognition Battery (NIHTB-CB) norming project (Weintraub et al., 2013). Based on prior studies (Gasquoine et al., 2007; Ardila, 2005; Jacobs et al., 1997; Boone et al, 2007), we hypothesized that demographically-matched NH Whites would perform better on the NIHTB-CB overall, and on most subtests than the Hispanic group, and within Hispanics, Hispanic-English would perform better than Hispanic-Spanish individuals. We also sought to determine the contribution of language use and cultural background factors on neuropsychological performance across the different language/ethnic groups. This is important for enhancing multicultural understanding and interpretation of neuropsychological test scores in clinical and research settings. Although the norming of the NIHTB-CB was done separately for English- and Spanish-speaking Hispanics, and therefore at least partially controls for linguistic backgrounds on those particular tests, this is not the case for most neuropsychological tests and test batteries. Thus the current analyses highlight the importance of uncontrolled linguistic and related cultural factors more generally on tests of various cognitive constructs.

Method

Participants

Participants included 279 healthy adults from the national normative study for the National Institutes in Health Toolbox for the Assessment of Neurological and Behavioral Function (Gershon et al., 2013). To be included in the current study participants had to be 18 years or older and self-identify as Hispanic or NH White. Hispanic participants self-identified language of preference (e.g., those who identified Spanish as their preferred language were tested in Spanish). Self-selection of language administration was chosen in order to enhance ecological validity and representation of how the NIHTB-CB will be utilized in clinical settings, and also to help increase the variability of linguistic factors among those tested in English and Spanish (e.g., level of bilingualism). From the sample of NIH-TB normative participants who met these inclusion criteria (719 NH White, 100 Hispanic-English, and 408 Hispanic-Spanish), we selected 93 NH Whites, 93 Hispanic-English, and 93 Hispanic-Spanish, who were one-to-one matched on age, education (±2 years) and gender, blind to any additional data beyond these demographics. Of note, our Hispanic-English cohort in the current study included almost all of the Hispanic participants from the normative English speaking study sample, which was the smallest of the three groups (n=100 in the normative sample versus n=93 in the current sample). Thus, the Hispanic-English was the primary reference group used as comparison for one-to-one demographic matching with the NH White and Hispanic-Spanish groups. For further details regarding the English and Spanish speaking normative groups, please see Casaletto et al 2015 and 2016. Hispanic-Spanish individuals included in the current study, however, were significantly younger (40.7 vs. 45.1 years, $p=0.02$) and had higher levels of education (13.6 vs. 9.9 years, $p<0.001$) as compared to those in the overall normative Hispanic-Spanish sample. Additionally, NH Whites in the current subsample were significantly younger (40.6 vs. 53.3, $p<0.001$) than those in the remainder of the overall normative sample. Our final sample of participants (n=279) ranged in age from 18 to 83 years, had between 9 and 20 years of education, and a majority were female (77%). Table 1 provides a summary of demographic and background information available for each language/ethnic group. Values are missing for certain variables because some participants did not complete the corresponding questionnaire.

Materials and Procedures

NIH-TB Cognition Battery Measures—As noted, the data used for this research were collected as part of the NIH-TB normative study. The NIH-TB includes four different modules, one of which is the NIHTB-CB. The NIHTB-CB is a 30-minute, computerized cognitive assessment and was designed to assess Fluid (Attention, Executive Function, Episodic Memory, Processing Speed, Working Memory) and Crystallized (Language) abilities, using seven different tests (Heaton et al., 2014). The Fluid Composite is an average of the Dimensional Change Card Sort Test, Flanker Inhibitory Control and Attention Test, List Sorting Working Memory Test, Picture Sequence Memory Test, and Pattern Comparison Processing Speed Test. The Crystallized Composite is comprised of the Oral Reading Recognition Test and Picture Vocabulary Test. Of note, the Crystallized language measures (Oral Reading and Picture Vocabulary) were developed separately for English and Spanish speakers and are not intended to be comparable in the two languages. Because it would not be meaningful to directly compare the English and Spanish versions of these measures between those tested in Spanish versus English, we only examined the Crystallized measures within the language groups (i.e., within the Hispanic-English and NH White together, and within the Hispanic-Spanish separately), in order to assess relationships with potentially relevant background factors (see below). The details of the tests comprising the NIHTB-CB have been reported in detail previously (Weintraub et al. 2013), and we describe them only briefly here.

Dimensional Change Card Sort test (DCCS)—The DCCS measures cognitive flexibility (set shifting) by presenting visual stimuli that must be matched to one of two images according to shape or color. There are three sets of trials: one set requires sorting to color, another to shape and the third required switching according to instructions between color and shape matching. A total of 40 trials are completed in 4 minutes. Scores represent reaction time,

Flanker Inhibitory Control and Attention test (Flanker)—This test measures attention and executive function by testing the ability to inhibit attention to irrelevant task dimensions. A central directional arrow is flanked by arrows on the left and right. On congruent trials, the flankers face the same direction as the center arrow. On incongruent trials, the flankers face the opposite direction. The task is to quickly indicate the direction the central arrow is facing with the computer keyboard. A total of 40 trials are completed in

4 minutes. Scoring is similar to that of the DCCS task, i.e., they are based upon reaction time.

List Sorting Working Memory test (List Sorting)—As the name of the test indicates, the List Sorting test measures working memory. A series of images are presented visually and orally, one at a time. Participants must repeat the stimuli in order of size, from smallest to largest. One category of stimuli is presented in the first condition. Two categories of stimuli are presented in the second condition, following which the participant must repeat the stimuli in order of size from one category, then from the other. This test takes 7 minutes to complete. Scores represent the number of correct items across all trials.

Picture Sequence Memory (Picture Memory)—Pictured objects and activities are presented thematically in a fixed spatial order. After the stimuli are moved from the center of the screen in a random display, participants must place the stimuli in the order in which they were first presented, as accurately as they can. The Picture Sequence Memory test takes approximately 10 minutes to administer. Test scores represent the total number of adjacent pictures remembered correctly over 3 learning trials.

Pattern Comparison Processing Speed test (Pattern Comparison)—Participants are presented with visual patterns and are asked to quickly identify whether the two patterns presented are the same or not. Total administration time is 3 minutes. Test scores represent the number of correct items (out of 130 items) completed in 90 seconds.

Oral Reading Recognition test (Reading)—The Reading test is a computerized adaptive test measures the participant’s ability to pronounce single words that are presented in printed form. The words are presented one by one and the participant is asked to read them aloud. On average, 30 to 40 words are presented within a computer adaptive format and the administration time is 4 minutes.

Picture Vocabulary test (Vocabulary)—The Vocabulary test, another computerized adaptive test, measures the ability to understand meaning of single words. For this task, words are presented orally and are paired with four images of objects, actions, or concepts. Participants must match the spoken word to a picture that best defines or represents the word. Average administration time is 5 minutes.

Language/Cultural Background Variables

Participants self-reported the following language/cultural background variables: a) main language spoken at home (English, Spanish, English and Spanish equally, or some other language); b) first language learned (English, Spanish, or some other language); c) whether they went to school in the U.S.; d) whether they were born in the U.S.

Current Frequency of Language Use—Participants were asked to rate, separately, how frequently they use English and Spanish in everyday life using the following response options: 1 (none), 2 (rarely), 3 (often), 4 (every day). We created an indicator of the most frequent language use, which combined these values for English and Spanish frequency into three categories: dominant English use (3 or 4 on English use, and 1 or 2 on Spanish use), dominant Spanish use (3 or 4 on Spanish use, and 1 or 2 on English use), and Balanced Language Use (equal ratings on English and Spanish use).

Data Analysis

We developed sample-based T-scores (TS) (uncorrected for demographics) for each of the Fluid NIHTB-CB measures based on the mean and standard deviation of our three groups, combined (i.e., uncorrected TS). These T-scores were computed using raw scores that were converted into sample-based z-scores and then transformed into the T-metric. Given that the Crystallized language measures (Reading and Vocabulary) were not developed to be directly comparable in English and Spanish, we created sample-based TS for the English- and Spanish-speaking cohorts, separately, and only examined these scores within each language group. For Fluid test measures, we used between-subjects analyses of variance (ANOVA) to examine differences in NIHTB-CB performances (composites and individual measures) across language/ethnic group, followed by pairwise comparisons with Tukey's correction.

Within each of the language/ethnic group, we then examined the impact of language and cultural background variables on uncorrected NIHTB-CB performances via ANOVAs or Spearman's correlations, as appropriate. We report absolute values of Cohen's d effect sizes for all relevant analyses.

Results

As shown in Figure 1, significant group differences were found on the uncorrected Fluid Composite TS; $F(2, 275) = 8.07$, $p<.001$. Follow-up pairwise comparisons of Fluid Composite TS showed that Hispanics tested in Spanish performed worse than Hispanics tested in English ($p=0.01$) and NH Whites ($p<0.001$), with no significant differences between Hispanics tested in English and NH Whites. Using a −1 SD cut-point (T<40) to identify low scores, there was an increasing prevalence of such scores (i.e., false positive attribution of "impairment") on the uncorrected Fluid Composite across the race/ethnicity groups, such that weak Fluid Composite performance was found in 1.1% of NH Whites, 10.9% Hispanic-English, and 18.3% of Hispanic-Spanish ($p<0.001$). There were no significant differences between NH Whites and Hispanic-English individuals on the English version of the Crystallized Composite ($t(182) = 1.35$, $p=0.18$); again, Hispanic Spanish speakers were not included in this comparison because the reading and vocabulary tests were different for English and Spanish speakers.

Results on the individual measures comprising the Fluid Composite showed significant group differences on the Flanker ($F(2, 273) = 6.78$, $p=.001$), Pattern Comparison ($F(2,271) =5.80$, $p=.003$), and List Sorting ($F(2,271) = 13.29$, $p<.001$) tests. Hispanics tested in Spanish performed significantly worse on the Flanker and Pattern Comparison tests than both Hispanics tested in English ($ps<0.01$) and NH Whites ($ps<0.01$) (see Figure 1). Furthermore, both Hispanic groups performed significantly worse than NH Whites on the List Sorting test ($ps<0.01$), with no significant group differences between Hispanic subgroups ($p=0.09$).

Next, we examined the contribution of background factors on the NIHTB-CB Fluid and Crystallized Composite scores within each language/ethnic group. Within the NH White group there was not enough variability to examine the effect of these factors (see Table 1). Additionally, although there was variability within the Hispanic-English group, no language and/or cultural factors were found to be significantly associated with NIHTB-CB performances (ps>0.05). Nevertheless, within the Hispanic-Spanish group, individuals who attended school outside of the U.S. (t(71) =4.0, p<.001, Cohen's d=0.93), were more Spanish dominant by self-reported everyday language use (t(55) = −3.1, p=.003, Cohen's d =1.18), or reported speaking mainly Spanish at home (F(2,71) = 3.77, p=.03) performed more poorly on the Fluid Composite. On the other hand, *better* performances on the Crystallized (i.e., language) Composite were observed for Hispanic-Spanish individuals who attended school outside of the U.S. (t(71) =2.5, p=.016, Cohen's d=0.58), spoke more Spanish at home (F(2, 71) =10.2, p<.001; mainly Spanish *versus* mainly English: Tukey p<0.001 Cohen's d=1.56; Both Spanish/English *versus* mainly English: Tukey p=0.008 Cohen's d=1.03), were born outside of the U.S. (t(71) =5.1, p<.0001, Cohen's d=1.3), and learned Spanish as their first language (t(72) =3.1, p=.003, Cohen's d=1.30). Similar analyses controlling for demographics (i.e., age, education, sex) yielded similar results.

We then examined the background factors associated with individual Fluid measures that differed between the groups (i.e., List Sorting, Flanker, and Pattern Comparison; Figure 1). Again, no background factors were associated with individual cognitive test performance in the Hispanic-English group. However, among the Hispanic-Spanish group, significantly worse performances on the Flanker test were seen with those who attended school outside of the U.S. (t(71) = 3.7, p<.001, Cohen's d=−0.87), were Spanish dominant (t(55) = −3.2, p=.002, Cohen's d=1.24), and spoke mainly Spanish at home (F(2,71) = 5.38, p=.007; *versus* both English and Spanish equally at home: Tukey p=0.008, Cohen's d=0.82). Similarly, on Pattern Comparison, those who went to school outside of the U.S. (t(70) = 4.2, p<.001, Cohen's d=0.98), spoke mainly Spanish at home (F(2,70) = 4.49, p=.015; *versus* speaking mainly English at home: Tukey p=0.02, Cohen's d=0.90), and were born outside of the U.S. (t(70) = 4.0, p<.001, Cohen's d=1.05), performed significantly worse. Finally, on the List Sorting test, Hispanic-Spanish individuals who were Spanish dominant (t(55) = −2.6, p=.012, Cohen's d=0.99), but spoke mainly English at home (F(2,71) = 3.51, p=.035; *versus* speaking Spanish and English equally at home: Tukey p=0.03, Cohen's d=1.04) performed significantly worse.

Lastly, we examined whether there were any residual differences among the language/ethnic groups after applying the NIHTB-CB normative standards. These normative standards were developed separately for English and Spanish speakers by racial/ethnic group and were fully corrected for demographic factors (i.e., age, sex, education, race/ethnicity, language of administration; Casaletto et al., 2015). Using these normative standards, there were no subsequent group differences on Fluid or Crystallized TS (Fluid: F(2,238) =1.34, p=0.27; Crystallized: F(2,249) = 0.33, p=.72).

Discussion

In this study, we compared performances on the NIHTB-CB across demographically-matched Hispanics tested in Spanish, Hispanics tested in English and Non-Hispanic Whites tested in English. Language and cultural background variables such as language mainly spoken at home, first language learned, and whether or not individuals went to school and were born in the U.S., were also examined as factors that may affect performance. Results demonstrated that Hispanic-Spanish individuals performed worse on Fluid Composite scores than Hispanic-English and NH Whites, who did not differ from each other. Within the Fluid composite, we found significant group differences in performance between Hispanic-Spanish, Hispanic-English, and NH Whites on measures of attention/inhibition, processing speed, and working memory. As such, the current study adds to the available literature by documenting differences in neuropsychological performance across language/ethnic groups on the NIHTB-CB, which was specifically designed for use in both English- and Spanish-speaking populations. Findings also demonstrated the significant impact of language/cultural background variables on neuropsychological scores, highlighting the importance of evaluating these factors, particularly in neuropsychological assessments of Spanish-speaking Hispanics in the U.S. (the current results may not generalize to other countries). Within the Hispanic-Spanish group, crystallized abilities were positively associated with speaking less English and completing education outside the US, while Fluid abilities were negatively associated, even when tested in Spanish.

Our primary finding that Hispanics tested in Spanish performed worse than both Hispanics and NH Whites tested in English on the Fluid composite is consistent with previous studies showing significant language group differences on neuropsychological test performances (Mungas et al., 2005; Jacobs et al., 1997). For example, Mungas and colleagues (2005) found a global language effect on the SENAS scores, wherein greater English use was positively associated with performance on all scales and greater Spanish use was associated with poorer performance. In the present study, however, these language group differences appeared to be driven by performances on two individual NIHTB-CB tests of attention and inhibitory control (Flanker test) and processing speed (Pattern Comparison test). Differences among normal, community-dwelling groups on these tests and the overall Fluid Cognition composite, are of particular importance to neuropsychologists. Fluid cognition measures are considered most sensitive to acquired brain dysfunction and failure to consider relevant background influences on such tests are likely to result in excessive false positive errors in classifying “impairment” in U.S. Spanish speakers. For this reason, the NIHTB-CB has been normed separately for Spanish and English speakers (Casaletto et al, 2015). When these NIHTB-CB norms are used performance was comparable across groups in the current study.

Of note, such separate norming by language group is not available for most neuropsychological tests. In interpreting results of Spanish-speaking Hispanics on tests that were normed only with English-speakers, one should be aware that the available norms for most tests may well overclassify “impairment”. Also, when testing Spanish-speakers, our findings suggest it is important to inquire about and consider these background variables shown to be significant here. When interpreting the current group differences on Fluid tests, it is important to keep in mind that Spanish- and English-speaking language versions of the

NIHTB-CB Fluid cognition measures are virtually the same, except for language of test instructions and translated word stimuli only on the List Sorting test. It is unlikely that differences in language of test administration accounted for differences in fluid cognition, as the Hispanic-English and Hispanic-Spanish groups performed equivalently on List Sorting.

Interestingly, among the Hispanics tested in Spanish, language/cultural background factors were associated with NIHTB-CB test scores, such that speaking more Spanish and being born or educated outside of the U.S. were associated with poorer Fluid performances. This finding is consistent with the prior findings that bilingualism may have a positive impact on executive functioning, such that the Hispanics in the current study who were considered to have balanced language use (i.e. spoke more English) performed better on Fluid measures (Carlson & Meltzoff, 2009; Bialystok, 2009; Armengol, 2007). While recognizing that we did not have a formal measure of acculturation, the fact that frequency of Spanish use in the U.S. is associated with lower levels of acculturation (Coronado et al., 2005; Thomson & Hoffman-Goetz, 2009; Llorente, 2008; Gasquoine, 1999), suggests that another potential explanation is that these observed differences are reflecting effects of acculturation on the NIHTB-CB. For instance, Razani et al. (2007) found that higher acculturation levels can positively impact attention, executive function, and processing speed performances (i.e., Trail Making Test Part B, Digit Span, Stroop Test). Perhaps more exposure to Anglo-American culture, especially in test-taking settings like U.S.-based education, allows one to become familiar with the timed testing approach, among other requirements of these tests. Therefore, it is possible that when Hispanic-Spanish individuals experience greater exposure to the dominant Anglo-American culture, their scores on neuropsychological tests, particularly those with a timed component, may increase due to an increased knowledge and experience in speeded test-taking formats and other emphases of U.S. education (Razani et al., 2007). Moreover, the role of education experience (quality of skill level attained, and/or the country in which the skills were attained) could greatly influence performance on the kinds of Fluid cognition tasks included in the NIHTB-CB. For example, in the U.S., speed is valued and schools may more strongly reinforce the idea that fast performance leads to better results, compared to Hispanic culture in which speed and quality are often considered contradictory, and a slow and careful process is thought to lead to better results (Ardila, 2005). It is also now well established that quality of education, in addition to quantity (years of schooling), may be an important factor to consider when examining individuals from disparate language/cultural backgrounds (Jacobs et al., 1997; Manly et al, 2004). Differences in quality of education have been shown to account for some racial differences in neuropsychological performance among Non-Hispanic Blacks and Whites (Manly et al., 1998; Manly et al, 2002). It is important to note, therefore, that matching our study groups on the basis of years of education completed would not have controlled for any such qualitative differences.

We could not directly examine Crystallized abilities across language of test administration because the reading and vocabulary tests in English and Spanish were not developed to be comparable measures. Nevertheless, it is of interest that, within the Hispanic-Spanish group, indicators of less acculturation and monolingualism (e.g., speak Spanish at home) positively impacted Crystallized abilities when tested in Spanish. That is, perhaps not surprisingly, more exclusive experience with the Spanish language (e.g., educated in Spanish-speaking country) resulted in better Spanish language skills.

Conversely, a different pattern of results was seen on our working memory measure (List Sorting Test), such that both Hispanic groups performed worse than the NH White group, regardless of which language they were tested in. This decreased performance in both Hispanic groups suggests that there could be one or more factors that are common to both groups of Hispanics that might explain a reduced level of performance. However, it is worth noting that List Sorting is the only Fluid test that has words with different numbers of syllables for the stimuli in English and Spanish, and thus different mechanisms within each language group might be explaining the overall group differences. For Hispanics tested in Spanish, poorer performances on List Sorting might have been influenced by a higher working memory load introduced by a word-length effect. That is to say, the Spanish version of the List Sort was qualitatively observed to have words with more syllables, while the English version of List Sorting had fewer. For example, a simple two-syllable word like *popcorn* was translated to a more complex seven-syllable term *palomita de maíz* on the Spanish version. There is evidence from previous research supporting the concept of a word-length effect, such that immediate memory span decreases as word length increases in syllables (Baddeley, 2003). Somewhat inconsistent with this interpretation of an increased language burden on Spanish-speaking Hispanics on the List Sorting test relative to NH Whites, we found that within the Hispanic-Spanish group, individuals who met criteria for balanced language use (but presumably greater U.S. acculturation), who may not perform as well on language tasks than for monolingual Spanish-speakers, performed better on List Sorting. It might be the case that the positive effect of bilingualism on executive function is counteracting the increased language difficulty in this group. Future studies that include additional information on history and current language use, might help shed further light on these seemingly irreconcilable findings.

Although we did not find any language/cultural background factors to be associated with Hispanic-English performance, one possible hypothesis for their observed decrement in List Sorting performance compared to NH Whites may be the heavy verbal/language load. Specifically, the List Sorting test has a demanding language component and requires participants to orally list a set of words in a specific order. Alternatively, or perhaps in addition to the load of word length, there may be a primary language effect impacting performances on the List Sort test. Specifically, given that there was a high prevalence of balanced language use in the Hispanic-English cohort (86%) and that knowledge of Spanish words can interfere with the production of English words (Altarriba & Heredia, 2008), perhaps some of the Hispanic-English individuals indeed had slightly weaker English language abilities which may have adversely impacted their List Sorting performance. Though not statistically significant (p=0.18), there was a trend towards poorer performances in the Hispanic-English compared to the NH White performance on language abilities (e.g., Crystallized Composite).

The strengths of our study include our relatively large sample sizes for each demographically matched language/ethnic group and completion of neurocognitive measures developed to be comparable in English and Spanish. However, the present study also has limitations that need to be addressed. Our study exclusively examined self-reported background measures. For instance, there were no direct or objective measures for acculturation and bilingualism; however, currently there are no globally accepted measures for classifying bilingualism on the basis of an objective scale due to its varying definitions. Similarly, much debate has surrounded acculturation and which measures best assess it, though the indices used in the current study (i.e., location of birth/education and current language usage) are commonly used indicators. Future studies would benefit from more comprehensive and objective methods to assess acculturation through the use of multiple acculturation scales in order to capture the numerous aspects of acculturation (Unger et al, 2007). Additionally, although based upon self-report, our study utilized variables (English and Spanish use frequency) that are typically included in validated measures of bilingualism (e.g., Bilingual Language Profile), and represents a global approach to measuring language use (Carlson & Meltzoff, 2008; Pienemann & Kessler, 2007; Birdsong, Gertken, & Amengual, 2012). Although not available in the current study, other variables associated with health related outcomes, such as immigration status, country of origin, socioeconomic status, and age at which English/Spanish was first learned could have been useful in explaining the groups' performances. For instance, Razani et al. (2007) report that early exposure to and mastery of English are better indicators of cognitive test performances than current use of English. Furthermore, caution is warranted in interpreting results and overgeneralizing to all Hispanics, as they are a very heterogeneous group (e.g. having differing educational and cultural experiences from multiple countries). As observed in our cohort, those tested in English or Spanish evidenced a variable pattern of similarities (e.g., DCCS) and differences (e.g., Flanker) on test performances. In addition, due to the nature of the English-dominant NH White group, there was not enough language background variability to explore any effects of language on NH White performances. Although this may reflect language usage in the general, U.S. NH White population, the lack of variability in language use limits our ability to determine how these language factors affect performances across ethnicity.

Overall, our findings indicate that Hispanics living in the U.S., particularly those who prefer to be tested in Spanish, performed more poorly on the NIHTB-CB Fluid cognition measures than NH Whites. These differences were most apparent on tests of processing speed, attention, executive function, and working memory. Among Hispanics tested in Spanish, language and cultural background variables were found to differentially impact Fluid and Crystallized measures (i.e., more Spanish and less acculturation were associated with worse performance on Fluid and better performance on Crystallized). These results highlight the important role that culturally relevant factors play in neuropsychological performance among Hispanics. Additionally, these results demonstrate that the examinee's experience base can impact neuropsychological performance in complex ways. For clinicians, it is important that these factors be taken into account when interpreting cognitive capacities among individuals of non-majority language/ethnic backgrounds, particularly when norms are used that are not specific to people with the examinee's background. Without knowledge of these cultural factors, it is possible to over-interpret low scores among Hispanics and, consequently, make inaccurate diagnoses. Misclassification of this group has potentially harmful consequences for the patient, family, and healthcare system (e.g., alterations in perception of self, behavior may be influenced, delay in correct diagnosis). The availability of separate norms on the NIHTB-CB for Spanish-speaking Hispanics clearly should improve interpretation of results on this particular battery but as noted, most major neuropsychological tests do not have separate norms for Spanish-speaking Hispanics. As the Hispanic population continues to grow and as the field moves forward, future studies are needed to address the impact of additional factors (e.g., healthcare outcomes, SES, when was English first learned, etc.) not included in this study to best address the question of which non-clinical factors have the greatest impact on Hispanic neuropsychological performance.

Acknowledgments

Funding

This study was supported by the following National Institutes of Health grants: F31-DA035708, T32-DA31098, K23MH 105297, and the HIV Neurobehavioral Research Center (HNRC; P30MH062512 NIMH). It was also supported (in part) by the Advancing Diversity in Aging Research Program (ADAR:5R25AG043364-02 NIH).

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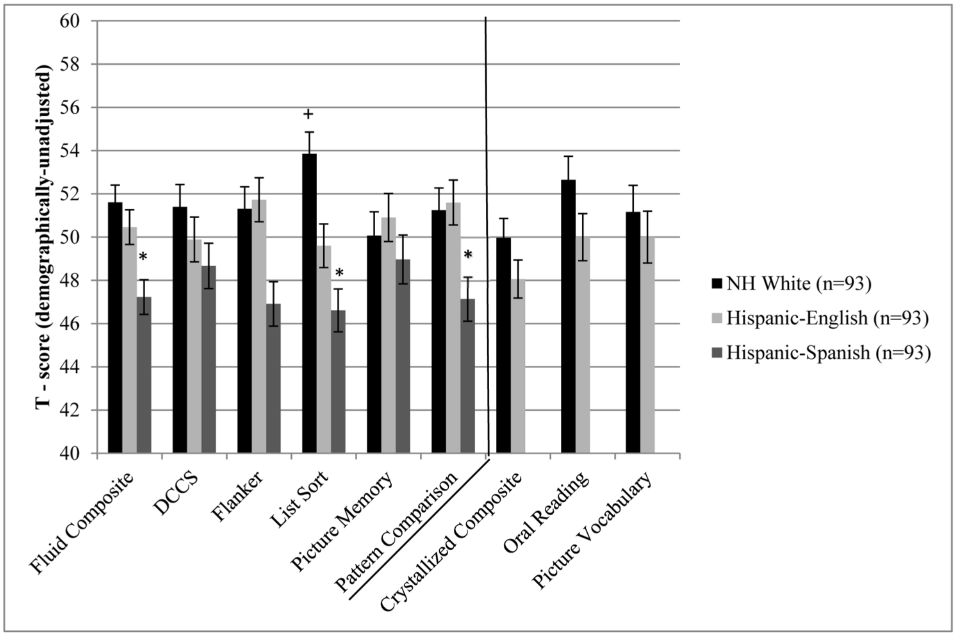

Figure 1.

NIHTB-CB Performances by ethnic and language group on the Fluid Composite, Crystallized Composite, and individual tests. T-scores represent demographically-unadjusted scores, which were created by converting raw scores based on the present sample (i.e., they are not based on NIHTB CB normative standards).

Note. DCCS: Dimensional Change Card Sort Test; Flanker: Flanker Inhibitory Control and Attention Test; List Sort: List Sorting Working Memory; Picture Memory: Picture Sequence Memory; Pattern Comparison: Pattern Comparison Processing Speed Test

* Hispanic-Spanish (Hispanics tested in Spanish) differed from both Hispanic-English (Hispanics tested in English) and NH White (Non-Hispanic White) (*ps*<0.05)

+ NH White differed from Hispanic-English and Hispanic-Spanish (*ps*<0.05).

Table 1

Demographic and Background Characteristics of the Demographically-matched Study Samples.

	NH White (*n*=93)	Hispanic-English (*n*=93)	Hispanic-Spanish (*n*=93)	*p*-value[†]
Demographic Characteristics				
Age, years (*M*, *SD*)	40.6 (15.1)	40.5 (15.1)	40.7 (15.3)	0.99
Gender (% Male, *n*)	33.3% (31)	33.3% (31)	33.3% (31)	1.00
Education, years (*M*, *SD*)	13.9 (2.3)	13.9 (2.5)	13.6 (2.4)	0.64
Language/Background Characteristics				
Language Spoken at Home (%, *n*)				<0.0001
English	98% (50)	78.6% (55)	16.2% (12)	
Spanish	0.0%	2.9% (2)	56.8% (42)	
English & Spanish Equally	2% (1)	18.6% (13)	27% (20)	
First Language Learned (%, *n*)				<0.0001
English	96.1% (49)	51.5% (35)	8.1% (6)	
Spanish	0.0%	44.1% (30)	91.9% (68)	
Some other language	3.9% (2)	4.4% (3)	0.0%	
School in United States (% Yes, *n*)	96.1% (49)	91.4% (64)	54.8% (40)	<0.0001
Born in United States (% Yes, *n*)	98% (49)	81.4% (57)	28.8% (21)	<0.0001
Current Frequency of Use (%, *n*)				<0.0001
Dominant English Use	96.1% (49)	55.4% (31)	0.0%	
Dominant Spanish Use	0.0%	0.0%	14% (8)	
Balanced Language Use	3.9% (2)	44.6% (25)	86% (49)	
Missing	42	37	36	

[†] p-values based on ANOVA and Chi-square tests.

Note. Language/Background data missing on: n=42 Non-Hispanic White (NH White) missing, n=23 Hispanic-English missing; n=19 Hispanic-Spanish missing.