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UDSNB 3.0 Neuropsychological Test Norms in Older Adults from a Diverse Community: Results from the Einstein Aging Study (EAS)

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Abstract

Background: The Uniform Data Set, Version 3 Neuropsychological Battery (UDSNB3.0), from the database of the University of Washington's National Alzheimer's Coordinating Center (NACC), is widely used to characterize cognitive performance in clinical and research settings; however, norms for underrepresented community-based samples are scarce.

Objective: We compared UDSNB 3.0 test scores between the Einstein Aging Study (EAS), composed of racially/ethnically diverse, community-dwelling older adults aged ≥ 70 and the NACC, and report normative data from the EAS.

Methods: Analyses included 225 cognitively normal EAS participants and comparable data from 5,031 NACC database participants. Linear regression models compared performance between the samples, adjusting for demographics (sex, age, education, race/ethnicity), depressive symptoms, and whether English was the first language. Linear regression models to examine demographic

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factors including age, sex, education and race/ethnicity as predictors for the neuropsychological tests were applied in EAS and NACC separately and were used to create a demographically adjusted z-score calculator.

Results: Cognitive performance across all domains was worse in the EAS than in the NACC, adjusting for age, sex, education, race/ethnicity, and depression, and the differences remained in visuo-construction, visuospatial memory, confrontation naming, visual attention/processing speed, and executive functioning after further adjusting for whether English was the first language. In both samples, non-Hispanic Whites outperformed non-Hispanic Blacks and more education was associated with better cognitive performance.

Conclusion: Differences observed in demographic, clinical, and cognitive characteristics between the community-based EAS sample and the nationwide NACC sample suggest that separate normative data that more accurately reflect non-clinic, community-based populations should be established.

Keywords

Aging; cognitive test norms; community sample; mild cognitive impairment; neuropsychology; racial/ethnic diversity

INTRODUCTION

The original neuropsychological battery of the Uniform Data Set (UDSNB) was created by the National Institute on Aging Alzheimer Disease Centers Clinical Task Force in 2005 for the assessment of cognitive performance in dementia and mild cognitive impairment due to Alzheimer's disease and related disorders [1]. The primary goals were to develop a standard battery for the collection of longitudinal data and to encourage collaboration across Alzheimer Disease Research Centers (ADRCs) for consistent characterization of participants as having normal cognition, mild cognitive impairment, or dementia [2]. In 2015, the neuropsychological battery was updated to a third version (UDSNB 3.0) with the intent to reduce practice effects, replace earlier measures with nonproprietary or newly developed ones, expand the assessment to neurocognitive domains not previously targeted, and maintain longitudinal continuity with previous datasets [3]. The UDSNB 3.0 is freely available for research purposes to support consistent and systematic data collection [3], with data maintained at the National Alzheimer's Coordinating Center (NACC) [4].

The UDSNB 3.0 consists of eight tests that measure global cognition and specific domains (i.e., memory, language, visuospatial/visuo-constructional skills, and attention/working memory/executive attention) [3]. Since its update, a substantial amount of work has been done to support the widespread use of the UDSNB 3.0 including publishing normative data for > 3500 cognitively intact older adults [3] and using normative data to create additional indices and derived measures relevant for clinicians and researchers (i.e., trail-making and verbal fluency discrepancy scores, memory retention indices, and an error index) [5]. Recently, Sachs et al. [6] expanded the UDSNB 3.0 normative data to include race/ethnicity-adjusted norms for Black/African-Americans and Whites.

Demographic variables, such as age, sex, and education are widely known to impact neuropsychological performance and are commonly adjusted for in the normative data for many tests [7, 8]. Older age and fewer years of education are consistently associated with poorer performance [8–10], while sex differences vary depending on the cognitive domain being measured [11–14]. Racial/ethnic minorities tend to demonstrate worse performance across multiple cognitive domains [15–22]; subsequently, one approach is to use normative data for separate racial/ethnic groups, as is commonly done with other demographic variables [23–25]. Race/ethnicity is thought to be a proxy for social factors that affect test performance such as quality of early education, acculturation, and health environments [26–29].

Currently available normative data for the UDSNB 3.0 have several strengths. They include a large national sample, race-adjusted scores, and a user-friendly calculator to derive demographically-adjusted scores [3, 6]. However, there are also several drawbacks. The current normative standards predominately utilize data from ADRCs [3, 6], and these data may not be representative of the overall population of older adults in the U.S. [30–32]. Participants from memory clinics tend to be relatively healthier, more functionally independent in activities of daily living, and better-educated [33–35]. In addition, despite the documented impact of native language status on neuropsychological test performance [29, 36, 37] and the fact that 21% of the U.S. population speaks a language other than English at home [38], this variable has yet to be explored within the UDSNB 3.0. Because of the increasing popularity of the UDSNB 3.0, it is of vital importance to increase representativeness in the normative sample to avoid misdiagnosis and to improve the applicability and generalizability for diverse, community-based populations. In the current study, we report the demographic and clinical characteristics of a community-based cohort and that of the NACC. We compare cognitive performance in the previously reported UDSNB 3.0 normative data with those derived from the Einstein Aging Study (EAS) [39, 40], which enrolls and tests a systematically-recruited, community-residing, racially/ethnically diverse cohort of older adults from the Bronx, NY. We present neuropsychological norms, adjusted for age, sex, education, and race/ethnicity from this non-clinic-based cohort of cognitively-normal older adults.

METHODS

Participants

Analyses were based on data from the current EAS cohort and from the UDSNB 3.0 data submitted to NACC by participating ADRCs. The EAS is a longitudinal study of community-residing individuals, aged 70 and older, in the Bronx, New York, a racially and ethnically diverse urban setting [39]. Since 2004, EAS participants have been recruited systematically using Bronx County Voter Registration lists. Individuals were mailed introductory letters and were phoned 7–10 days after to complete a telephone screening and determine study eligibility. Those who met preliminary eligibility criteria were invited for further in-person evaluations. Participants were aged 70 years or older, non-institutionalized, ambulatory, and English speaking. Exclusion criteria included severe audiovisual, physical impairments or active psychiatric symptomatology, which interfered with the ability to complete assessments. The study was approved by the local IRB and participants provided written informed consent at baseline assessment. In-person assessments were conducted annually and included neurological and neuropsychological examinations, supplemental neuropsychological instruments, and ascertainment of demographics and clinical characteristics. In May 2017, the EAS added the UDSNB 3.0 to the in-person assessment battery. The analyses presented are based on the first administration of the UDSNB 3.0 for 225 EAS participants (46% non-Hispanic White, 39% non-Hispanic Black, 14% Hispanic), who had a global score of 0 ("normal cognition)" on the CDR® Dementia Staging Instrument (CDR®) [41] at the time of evaluation (May 2017 to December 2019).

The analyses presented were also based on UDSNB 3.0 data of 5,031 participants aged 70 years or older who had a global CDR® score of 0 in NACC from participating ADRCs between March 2015 and May 2019. While CDR of 0 was required, participants were not excluded based on low cognitive scores to avoid circularity, as was done in Sachs et al. [6]. Self- and co-participant reported subject health history was assessed only at the participants' initial UDS Version 3 visit. The sample sizes ranged from 3,864 to 5,026 depending on the specific UDSNB 3.0 test.

Cognitive tests for the UDSNB 3.0

A full description of the UDSNB 3.0 tests can be found in Weintraub et al. [3]. The core battery of cognitive tasks covers relevant domains for common neurodegenerative conditions. Briefly, the MoCA [42] is a measure of overall cognitive function and assesses aspects of memory, executive function, attention, concentration, language, abstract reasoning, and orientation, with a maximum score of 30. The Craft Story (version 21) [43] evaluates verbal episodic memory by reading a paragraph out loud to a participant and separately scoring the number of verbatim and paraphrase units recalled immediately and following a 30 min delay period. The 32-item Multilingual Naming Test (MINT) [44] is a test of confrontation naming, requiring oral naming of line drawings. Letter and category fluency are assessed, respectively, by having participants generate words beginning with a specified letter (Letter "F" and "L") or a category (Animals and Vegetables), each in 1 min. The Benson Complex Figure [45] assesses visuo-constructional ability by having the participant copy a complex geometric figure, followed by assessing memory by recall of the design after 10 to 15 min. Number Span evaluates simple attention and involves reading a string of numbers aloud to the participant and asking for verbatim recall (Forward Condition) or working memory via recall string of numbers in reverse order (Backward Condition). Trail Making Test Part A measures visual attention/speed of processing and requires the participant to connect numbers in a sequential ascending fashion. The more complex Trail Making Test Part B, considered to be a measure of executive functioning, adds a task switching element, and requires the participant to connect numbers and letters in sequential ascending fashion alternating between numbers and letters.

Demographic and clinical characteristics

Demographic information from the EAS and NACC included self-reported race/ethnicity as defined by the U.S. Census Bureau in 1994 (re-categorized to: non-Hispanic White, non-Hispanic Black, all others—White Hispanics, Black Hispanics, Asians, and multiracial), number of years of education, sex, and age. The NACC classification system (see naccdata.org) uses categories consistent with this re-categorization. Extended demographic information included marital status (married versus others), native language status (whether English was the participant's first language), and whether the individual lived alone. Body mass index (BMI), measured in kg/m^2 and calculated based on height and weight measurements, was used as a measure of obesity. The Geriatric Depression Scale (GDS, short form) was used to screen for depressive symptoms (range 0–15) [46]. Subject health history of hypertension and diabetes, available only at the initial UDS Version 3 visit in NACC, were also considered.

Data analysis

Baseline demographic, clinical characteristics and UDSNB 3.0 cognitive performance in the EAS and NACC were summarized and compared using the Wilcoxon Rank Sum tests for continuous variables and Chi-square or Fischer's exact test for categorical variables. We applied multiple linear regression models to compare the neuropsychological tests between the EAS and NACC samples adjusting for age (continuous), sex and education (continuous) (Model 1), and further adjusting for race/ethnicity (non-Hispanic White, non-Hispanic Black, and others, Model 2). To examine whether native language status and depressive symptoms confound the differences between the EAS and the NACC, English as first language (Model 3) and then GDS score were also added (Model 4). Multiple linear regression models were used to estimate the effect of age, sex, education, and race/ethnicity on each of the cognitive tests in the EAS and the NACC separately. Results were compared in the two samples using z-tests. A normative calculator for obtaining demographically adjusted z-scores based on the diverse community sample of EAS was also provided. Response times for the Trail Making Test (Parts A and B) were skewed and log-transformations were used in the sensitivity analysis, which did not change the conclusions. Therefore, the original variables were used in the reported results. All analyses were performed using SAS statistical software version 9.4 (SAS Institute, Inc., Cary, NC).

RESULTS

Table 1A shows the demographic and clinical characteristics for the EAS and NACC samples. The groups did not differ by age (EAS: 78.0±5.0 years versus NACC: 77.9±6.2 years, $p = 0.152$) or sex (% woman 68% versus 65%, $p = 0.414$), but the EAS sample had significantly less education (15.4±3.3 years versus 16.1±2.9 years, $p < 0.0001$) and was more racially diverse than the NACC sample (46% non-Hispanic White, 39% non-Hispanic Black, 14% Hispanic, and 1% other race/ethnicity in EAS versus 76% non-Hispanic White, 15% non-Hispanic Black, 6% Hispanic, and 3% other race/ethnicity in NACC, $p < 0.0001$). A higher proportion of EAS participants reported living alone (% live alone 50% versus 37%, $p = 0.0003$) and were not married (% married 38% versus 53%, $p < 0.0001$). The EAS sample also endorsed more depressive symptoms (GDS 1.8±1.4 versus 1.2±1.7, $p < 0.0001$), had higher BMI (28.9±5.2 versus 27.2±5.2, $p < 0.0001$), and had a lower proportion with English as the first language (80% versus 95%, $p < 0.0001$). EAS participants had significantly more medical comorbidities as measured by history of hypertension (68% versus 50%, $p < 0.0001$) and diabetes (22% versus 12%, $p < 0.0001$) (at initial visit of NACC). Table 1B shows the breakdown of demographic and clinical characteristics in groups stratified by race/ethnicity (non-Hispanic White, non-Hispanic Black, and all other race/ethnicity). The differences in depressive symptoms, native language status, and comorbidity between the EAS and NACC hold within each of the racial/ethnic groups.

Table 2 summarizes the UDSNB 3.0 test battery for the EAS and NACC samples. Generally, the overall performance in the EAS sample was worse than that of the NACC. Table 3 shows the estimates of mean differences in cognitive performance in the EAS versus NACC adjusting for demographics, native language status, and depressive symptoms. When adjusting for sex, age, and education (Model 1), the EAS sample had worse performance on measures of global cognition (MoCA), episodic memory (Craft Story 21), visuospatial skills (Benson Complex Figure Copy and Recall), attention (Number Span Forward and Backward), confrontation naming, L-word letter fluency, category fluency, visual attention/processing speed (Trail Making Test Part A), and executive functioning (Trail Making Test Part B). When adjusting further for race/ethnicity (Model 2), the differences between EAS and NACC performance persisted; non-Hispanic Blacks performed worse than non-Hispanic Whites across all tests, and other races/ethnicities also performed worse than non-Hispanic Whites across all tests except Benson Complex Figure Recall. Model 3 further adjusted for whether English is the first language spoken. Having English as the first language was associated with better cognitive performance in all tests except in the visuo-construction and visuospatial memory domain (Benson Complex Figure Copy and Recall), and the differences between the EAS and NACC samples in global cognition (MoCA), attention (Number Span Forward and Backward), and letter fluency were no longer significant. Finally, upon further adjusting for depressive symptoms (Model 4: Model 3 + GDS), a greater number of depressive symptoms (higher GDS score) was associated with worse cognitive performance, but conclusions about the comparisons between the EAS and NACC samples remained the same. This was also observed when GDS alone was added to Model 2 (not shown). Interestingly, the EAS sample performance in paraphrased measures of Craft Story 21 and F-word letter fluency was better than in the NACC sample after adjusting for race/ethnicity (Model 2) and became stronger and significantly better after further adjusting for whether English is the first language spoken (Model 3) and depressive symptoms in addition (Model 4). EAS sample performance was still worse, however, when compared to NACC on other measures including visuo-construction and visuospatial memory (Benson Complex Figure Copy and Recall), confrontation naming, visual attention/processing speed (Trail Making Test Part A), and executive functioning (Trail Making Test Part B). Further adjusting for obesity, subject report history of hypertension and diabetes did not change the findings (not shown). Since the proportion of those who spoke English as the first language was much lower in the ‘all other race/ethnicity’ category, we applied linear regression model adjusting for demographics and GDS (Model 2 + GDS), restricting it to participants with English as the first language and who were non-Hispanic Whites or non-Hispanic Blacks (not shown). The results remained similar to that found for Model 4 from the whole samples.

The differences between the EAS and NACC suggest that separate demographic adjusted norms are needed in the EAS. For this purpose, all the other race/ethnicity category was excluded due to its small sample size. Tables 4A and 4B shows results from multiple linear regression models for the outcome of specific UDSNB 3.0 neuropsychological tests using sex, age, education, and race/ethnicity (non-Hispanic Black versus non-Hispanic White) as predictors in the EAS (Table 4A) and in the NACC (Table 4B) as a comparison. In both the EAS and NACC samples, higher education was associated with better performance in the UDSNB 3.0. There were generally no strong associations of UDSNB 3.0 performance with age and sex within the EAS, though we recognize that power for detecting associations is lower in the EAS due to the smaller sample size. In contrast, older age was associated with worse cognitive performance in the NACC. Non-Hispanic Blacks generally performed worse than non-Hispanic Whites in global cognition (MoCA), episodic memory (Craft Story 21 delayed), visuospatial skills (Benson Complex Figure Copy), attention (Number Span Backward), letter fluency, category fluency (Animals), visual attention/processing speed (Trail Making Test Part A), and executive functioning (Trail Making Test Part B) in EAS, and across all cognitive domains in NACC. A normative calculator based on these results for obtaining demographic adjusted z-scores is described in the Supplementary Material and provided on the EAS website. This calculator is an example of how representative norms can be applied.

DISCUSSION

The current study derived normative data for the UDSNB 3.0 for cognitively-normal, community-dwelling racially/ethnically-diverse older adults from the Bronx, NY (EAS sample) and compared these data to recently updated NACC data on the same test battery [6]. Although recently published normative data for the UDSNB 3.0 included 15% non-Hispanic Black-Americans [6], participants were generally well-educated, spoke English as their first language, and were from specialized memory clinics—with fewer endorsed depressive symptoms and comorbid health conditions; thus, these individuals may not be directly comparable to EAS participants. Indeed, after controlling for sex, age, education, race/ethnicity and depressive symptoms, EAS participants performed significantly worse than NACC participants across measures of executive function, visual attention/processing speed, category fluency, simple attention and working memory, and naming, as well as global cognition. When further adjusting for native language status (i.e., English as a first language), the discrepancy between EAS and NACC scores remained significant on tests of visual-construction, visuospatial memory, language (naming and category fluency), visual attention/processing speed, and executive functioning. This motivated us to develop demographic-adjusted norms separately for the EAS. Using EAS norms, as expected, the percentages of low performance using commonly used cutoffs (e.g., at least 1, 1.5 or 2 SD below the demographic-adjusted mean) in 191 cognitively normal, non-Hispanic White or non-Hispanic Black EAS participants, were all within the expected range (i.e., within 95% CI of the expected level). However, when using NACC norms, the percentages of low performance were exceptionally high (beyond the expected upper limit) on several domains including naming, visual attention/processing speed, and executive functioning (ranges 26%–30%, 18–20%, 14–17% using 1, 1.5, and 2 SD below the mean, respectively). This may lead to misclassification of cognitive impairment within the EAS.

These results are important for several reasons. Our findings highlight that ADRC cohorts may not be representative of our non-clinic, community-based sample from the Bronx, even when norms are provided for individuals with "normal cognition." Specifically, in the present study, the EAS sample had lower educational attainment, was more racially diverse, and had a higher proportion of individuals with medical comorbidities (e.g., hypertension, diabetes), as compared to the NACC sample [6]. In addition, compared to the NACC sample, EAS participants had higher GDS scores, higher BMI, a higher proportion of individuals living alone, and lower proportions of individuals who were married or native English speakers. Of note, the EAS recruits reside in the Bronx, NY. The Bronx has the most diverse U.S.-born older adult population in New York and includes some of the poorest urban congressional districts in the country, with some of the poorest health metrics, including high rates of diabetes, obesity, heart disease, asthma, and HIV/AIDS [47–49]. Previous research documents the effects of native language status, childhood and adult socioeconomic status, and cardiovascular risk factors [29, 50–52] on cognitive function in older adults and these factors may contribute to worse lifetime performance in this study. Adjusting for education did not eliminate differences in the norms sampled, suggesting that years of education may not be the best indicator of quality of education. Measures such as the Wide Range Achievement Test [53] may provide an indicator that equalizes education across different state and local systems.

Our results also corroborate previous research examining the impact of native language on neuropsychological test performance. The EAS sample had a higher proportion of non-native English speakers than the NACC, and after adjusting for English as the first language, there were no differences between samples on measures of global cognition, simple attention and working memory, and letter fluency. Of note, these measures rely upon both receptive and expressive language skills, which may be more cognitively taxing for non-native English speakers. This is consistent with findings from Boone et al. [29] and Kisser et al. [36], who found that non-native English speakers have significantly worse performance on neuropsychological measures that require language processing (i.e., tests of language and attention). Taken together, our findings call attention to possible limitations to generalizability of current UDSNB 3.0 normative data. Differences observed in demographic, clinical, and cognitive characteristics between the community-based EAS sample and the nationwide NACC sample suggest that separate normative data that more accurately reflect community-based populations need to be established. Multiple studies provide a clear illustration of the danger of using norms from a demographically dissimilar group to interpret neuropsychological test data [54, 55] including diagnostic errors, unnecessary referral for additional assessment, inappropriate treatment, and the associated burden on health care, and unwarranted emotional distress on individuals and their families.

In cross-national neuropsychology where neuropsychological measures developed in the United States are translated or adapted for other countries, local norms are commonly created and used [56–58]. Within the U.S., there are challenges in norms development. These include small sample sizes, differences in defining the normative sample due to inclusion and exclusion criteria, and potential selection bias in recruitment [59]. These factors contribute to a call for action to develop representative norms [7, 60] to promote diagnostic accuracy in the interim, while large-scale wholly representative norms are still in development.

Several study limitations warrant mention. The sample size of EAS was modest and additional studies in larger samples are needed. While we gathered our own normative data to address the gap in representativeness of the NACC sample, large-population normative data is still preferable, provided it has appropriately similar demographics for a given individual. Of note, the EAS is ongoing and more data will be available in the future. Also, it is possible that some participants, classified as "cognitively normal" using the CDR® criteria, may be at the earliest stages of cognitive impairment. Consistent with Sachs et al. [6], participants were not excluded due to clinical diagnoses based on neuropsychological test information (e.g., DSM criteria) or low scores on neuropsychological tests (i.e., MoCA). We believe this is the most practical approach to prevent circularity of examining tests scores and clinical impressions, with the understanding we may introduce bias due to regional variation in rates of cognitive impairment/dementia.

Overall, we expanded currently available UDSNB 3.0 normative data for the racially/ethnically diverse older community-dwelling cohort of the Bronx, NY and compared it to the NACC sample. The findings call attention to the importance and applicability of representative norms for the UDSNB 3.0. Researchers and clinicians might seek to gather their own normative data to accurately reflect the demographics (i.e., racial/ethnic minority groups, lower educational attainment, comorbid health status, native English speaking) of the communities they serve. Through this effort and with the increasing popularity of the freely available UDSNB 3.0, more normative data from diverse community-based studies can be shared to promote diagnostic accuracy in age-related cognitive disorders and to be consistent with research priorities to include under-represented groups in ADRD research [61, 62].

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1A

Characteristics of study participants in EAS and NACC samples

Demographics	**N**	**EAS Sample**	**N**	**NACC Sample**	***p***
Age: *M (SD)*	225	77.97 (5.01)	5,031	77.86 (6.15)	0.152
Sex (#, % Female)	225	153, 68.0%	5,031	3288, 65.4%	0.414
Education: *M (SD)*	225	15.37 (3.28)	5,031	16.08 (2.93)	< 0.0001
Race/ethnicity					
#, % non-Hispanic White	225	104, 46.2 %	5,031	3843, 76.4%	< 0.0001
#, % non-Hispanic Black	225	87, 38.7 %	5,031	769, 15.3%	
#, % Hispanic	225	31, 13.8 %	5,031	282, 5.6%	
#, % Other Race/Ethnicity	225	3, 1.3 %	5,031	137, 2.7%	
GDS score: *M (SD)*	225	1.83 (1.44)	4,989	1.15 (1.72)	< 0.0001
BMI: *M (SD)*	218	28.90 (5.19)	4,829	27.23 (5.17)	< 0.0001
#, % Obese (BMI ≥30)	218	83, 38.1%	4,829	1206, 25.0%	< 0.0001
#, % English is the first language	224	179, 79.9%	5,027	4778, 95.0%	< 0.0001
#, % Married	224	85, 37.9%	5,015	2647, 52.8%	< 0.0001
#, % Living alone	224	111, 49.6%	5,025	1884, 37.5%	0.0003
#, % Diabetes	220	48, 21.8%	1,709	207, 12.1%	< 0.0001
#, % Hypertension	224	153, 68.3%	1,711	852, 49.8%	< 0.0001

GDS, Geriatric Depression Scale; BMI, body mass index; EAS, Einstein Aging Study; NACC, National Alzheimer's Coordinating Center.

Table 1B

Characteristics of study participants in EAS and NACC samples, stratified by race/ethnicity

Demographics	non-Hispanic White				non-Hispanic Black				Other Race/Ethnicity*			
	N	EAS	*N*	NACC	*N*	EAS	*N*	NACC	*N*	EAS	*N*	NACC
Age: *M (SD)*	104	78.43 (5.08)	3,843	78.09 (6.20)	87	77.83 (4.89)	769	77.57 (6.25)	34	76.92 (5.08)	419	76.21 (5.10)
Sex (% Female)	104	56%	3,843	62%	87	82%	769	81%	34	71%	419	72%
Education: *M (SD)*	104	16.44 (3.35)	3,843	16.51 (2.55)	87	14.48 (2.93)	769	14.93 (2.97)	34	14.35 (2.95)	419	14.28 (4.46)
GDS score: *M (SD)*	104	1.71 (1.44)	3,811	1.11 (1.69)	87	1.90 (1.36)	763	1.08 (1.55)	34	2.03 (1.66)	415	1.60 (2.17)
BMI: *M (SD)*	101	27.95 (5.33)	3,706	26.68 (4.79)	83	30.08 (4.91)	729	29.97 (6.05)	34	28.86 (5.00)	394	27.35 (5.27)
% Obese (BMI ≥ 30)	101	32.7%	3,706	22%	83	45%	729	43%	34	38%	394	25%
% English is the first language	103	83%	3,839	99%	87	98%	769	100%	34	26%	419	50%
% Married	103	50%	3,831	58%	87	22%	766	32%	34	41&	418	46%
% Living alone	103	47%	3,838	35%	87	61%	769	50%	34	29%	418	34%
% Diabetes	101	15%	1,257	9%	85	29%	244	24%	34	24%	208	20%
% Hypertension	103	53%	1,255	45%	87	83%	246	70%	34	76%	210	53%

* Other Race/Ethnicity includes Hispanic and other races/ethnicities (other than White or Black).

GDS, Geriatric Depression Scale; BMI, body mass index; EAS, Einstein Aging Study; NACC, National Alzheimer's Coordinating Center.

Table 2

Summary statistics for UDSNB 3.0 for cognitively normal participants in EAS and NACC samples

UDS Version 3 Neuropsychological Test**	Domain	Max Score	EAS Sample Scores				NACC Sample Scores			
			N	Mean (SD)	Q_{25}, Q_{50}, Q_{75}	Range	*N*	Mean (SD)	Q_{25}, Q_{50}, Q_{75}	Range
MoCA, total score *	Global Cognition	30	224	23.93 (3.66)	22, 25, 27	13–30	3865	25.54 (3.08)	24, 26, 28	4–30
Craft Story 21 recall immed. verbatim, total units *	Memory	44	224	18.66 (6.14)	14, 19, 23	2–44	3866	20.89 (6.63)	16, 21, 26	0–41
Craft Story 21 recall immed. paraphrase, total units	Memory	25	224	15.13 (3.98)	13, 15, 18	3–25	3866	15.54 (4.07)	13, 16, 18	0–25
Craft Story 21 recall delay. verbatim, total units *	Memory	44	224	15.18 (5.81)	11, 15, 19	2–32	3864	17.97 (6.73)	13, 18, 23	0–40
Craft Story 21 recall delay. paraphrase, total units *	Memory	25	224	13.70 (4.16)	11, 14, 17	2–24	3864	14.33 (4.36)	11, 15, 18	0–25
Benson complex figure copy, total score *	Visuospatial/Visuo-construction	17	224	14.90 (1.32)	14, 15, 16	10–16	4791	15.43 (1.49)	15, 16, 17	1–17
Benson complex figure recall, total score *	Memory	17	224	9.65 (3.28)	7, 10, 12	0–16	4779	10.52 (3.17)	9, 11, 13	0–17
Number span test forward, total correct trials *	Attention	14	225	7.27 (2.12)	6, 7, 9	3–14	3878	8.04 (2.32)	6, 8, 10	0–14
Number span test backward, total correct trials *	Working Memory	14	225	6.04 (2.08)	5, 6, 7	1–13	3874	6.85 (2.22)	5, 7, 8	0–14
MINT, total score *	Lang, naming	32	224	27.31 (4.17)	26, 28, 30	10–32	3849	29.62 (2.62)	29, 30, 32	1–32
F-words, total in 60 s	Lang, letter fluency	40	225	13.88 (4.60)	10, 14, 17	5–27	4821	14.22 (4.71)	11, 14, 17	0–35
L-words, total in 60 s *	Lang. letter fluency	40	225	11.84 (4.56)	9, 11, 15	1–26	4799	13.40 (4.47)	10, 13, 16	0–35
Total F- and L-words *	Lang, letter fluency	80	225	25.72 (8.44)	19, 25, 31	8–50	4798	27.55 (8.56)	22, 27, 33	0–64
Animals generation, total in 60 s *	Lang, category fluency	77	225	16.84 (4.80)	14, 16, 20	4–29	5026	19.95 (5.53)	16, 20, 23	3–49
Vegetables generation, total in 60 s *	Lang. category fluency	77	225	12.18 (3.86)	9, 12, 15	2–26	5013	14.21 (4.25)	11, 14, 17	0–36
Trail Making Test Part A, time (s) *	Visual Attention Processing speed	150	223	45.82 (18.60)	32, 43, 54	15–123	4993	35.24 (15.27)	26, 32, 40	12–150
Trail Making Test Part B, time (s) *	Executive functioning	300	225	136.51 (79.43)	81, 107, 174	41–300	4923	96.38 (53.73)	62, 81, 111	13–300

** Higher scores indicate better scores except for the Trail making test parts A & B.

* indicates statistical significance at $P < 0.05$.

Delay indicates delayed; immed, immediate; Lang. language; Max, maximum; MINT, multilingual naming test; MoCA, Montreal Cognitive Assessment; UDS, Uniform Data Set; EAS, Einstein Aging Study; NACC, National Alzheimer's Coordinating Center.

Table 3

Estimates of mean differences in UDSNB 3.0 performance between EAS and NACC samples (using NACC as the reference group) adjusting for demographics, native language status, and depression models

UDS Version 3 Neuropsychological Test**	Model 1: age, sex, education		Model 2: + race/ethnicity		Model 3: + native language status		Model 4: + GDS	
	Coefficient	p	Coefficient	p	Coefficient	p	Coefficient	p
MoCA, total score	−1.21	< 0.0001	−0.47	0.0114	−0.36	0.0549	−0.30	0.1070
Craft Story 21 recall immed. verbatim, total units	−1.77	< 0.0001	−1.11	0.0115	−0.81	0.0679	−0.72	0.1085
Craft Story 21 recall immed. paraphrase, total units	−0.10	0.7229	0.40	0.1333	0.60	0.0271	0.66	0.0157
Craft Story 21 recall delayed verbatim, total units	−2.31	< 0.0001	−1.50	0.0007	−1.26	0.0050	−1.16	0.0099
Craft Story 21 recall delayed paraphrase, total units	−0.28	0.3241	0.31	0.2715	0.51	0.0787	0.57	0.0486
Benson complex figure copy, total score	−0.47	< 0.0001	−0.31	0.0016	−0.29	0.0044	−0.27	0.0073
Benson complex figure recall, total score	−0.71	0.0007	−0.48	0.0245	−0.54	0.0124	−0.49	0.0243
Number span test forward, total correct trials	−0.61	< 0.0001	−0.36	0.0190	−0.25	0.1104	−0.22	0.1588
Number span test backward, total correct trials	−0.63	< 0.0001	−0.31	0.0319	−0.22	0.1288	−0.21	0.1537
MINT, total score	−2.04	< 0.0001	−1.35	< 0.0001	−0.95	< 0.0001	−0.93	< 0.0001
F-words, total in 60s	−0.04	0.8858	0.45	0.1508	0.60	0.0564	0.66	0.0382
L-words, total in 60s	−1.23	< 0.0001	−0.64	0.0282	−0.49	0.0978	−0.46	0.1194
Total F- and L-words	−1.21	0.0307	−0.13	0.8130	0.19	0.7365	0.27	0.6288
Animals, total in 60s	−2.74	< 0.0001	−1.82	< 0.0001	−1.65	< 0.0001	−1.59	0.0001
Vegetables, total in 60s	−1.89	< 0.0001	−1.49	< 0.0001	−1.28	< 0.0001	−1.20	0.0001
Trail Making Test Part A, time (s)	9.51	< 0.0001	6.84	< 0.0001	5.75	< 0.0001	5.35	< 0.0001
Trail Making Test Part B, time (s)	35.05	< 0.0001	23.94	< 0.0001	20.08	< 0.0001	18.15	< 0.0001

** Higher scores indicate better scores except for the Trail making test parts A & B.

Immed indicates immediate; MINT, multilingual naming test; MoCA, Montreal Cognitive Assessment; UDS, Uniform Data Set; EAS, Einstein Aging Study; NACC, National Alzheimer's Coordinating Center.

Table 4A

Multiple linear regression coefficients estimates and 95% confidence intervals (CI) for sex, age, education, and race/ethnicity in the EAS sample

UDS Version 3 Neuropsychological Test**	EAS Sample			
	Female	Age (y)	Education (y)	Non-Hispanic Black
	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)
MoCA, total score	1.21 (0.17, 2.24) *	−0.03 (−0.12, 0.07)	0.39 (0.24, 0.54) *	−2.27 (−3.28, −1.27) *
Craft Story 21 recall immed. verbatim, total units	0.66 (−1.33, 2.66)	0.11 (−0.08, 0.29)	0.34 (0.05, 0.62) *	−0.92 (−2.87, 1.02)
Craft Story 21 recall immed. paraphrase, total units	0.28 (−0.99, 1.55)	0.10 (−0.02, 0.22)	0.24 (0.06, 0.42) *	−1.02 (−2.26, 0.22)
Craft Story 21 recall delay. verbatim, total units	0.82 (−1.00, 2.63)	0.15 (−0.02, 0.32)	0.45 (0.19, 0.71) *	−2.19 (−3.96, −0.41) *
Craft Story 21 recall delay. paraphrase, total units	0.14 (−1.13, 1.42)	0.09 (−0.03, 0.21)	0.35 (0.17, 0.53) *	−1.55 (−2.80, −0.31) *
Benson complex figure copy, total score	0.05 (−0.38, 0.47)	−0.03 (−0.07, 0.00)	0.02 (−0.04, 0.08)	−0.42 (−0.83, −0.01) *
Benson complex figure recall, total score	−1.05 (−2.13, 0.04)	0.04 (−0.06, 0.13)	0.19 (0.04, 0.34) *	0.02 (−1.03, 1.07)
Number span test forward, total correct trials	0.50 (−0.16, 1.16)	0.01 (−0.05, 0.07)	0.14 (0.04, 0.23) *	−0.46 (−1.10, 0.18)
Number span test backward, total correct trials	0.44 (−0.19, 1.06)	0.04 (−0.02, 0.10)	0.17 (0.09, 0.26) *	−0.84 (−1.45, −0.23) *
MINT, total score	0.42 (−0.83, 1.68)	−0.10 (−0.21, 0.02)	0.32 (0.14, 0.50) *	−1.17 (−2.39, 0.06)
F-words, total in 60 s	1.55 (0.15, 2.96) *	0.11 (−0.01, 0.24)	0.34 (0.14, 0.54) *	−1.71 (−3.08, −0.34) *
L-words, total in 60 s	2.02 (0.67, 3.38) *	0.07 (−0.05, 0.19)	0.38 (0.19, 0.58) *	−1.87 (−3.19, −0.54) *
Total F- and L-words	3.58 (1.06, 6.10) *	0.18 (−0.05, 0.42)	0.72 (0.36, 1.08) *	−3.57 (−6.03, −1.12) *
Animals, total in 60 s	1.27 (−0.17, 2.71)	−0.10 (−0.23, 0.03)	0.26 (0.05, 0.46) *	−2.82 (−4.23, −1.41) *
Vegetables, total in 60 s	2.93 (1.79, 4.08) *	−0.02 (−0.13, 0.08)	0.27 (0.11, 0.43) *	−1.06 (−2.18, 0.06)
Trail Making Test Part A, time (s)	−2.83 (−8.36, 2.71)	0.37 (−0.14, 0.88)	−1.60 (−2.39, −0.80) *	10.89 (5.48, 16.31) *
Trail Making Test Part B, time (s)	−2.23 (−25.7, 21.27)	−0.25 (−2.41, 1.91)	−7.74 (−11.1, 4.38) *	39.69 (16.76, 62.63) *

** Higher scores indicate better scores except for the Trail Making Test Parts A & B.

* indicates statistical significance at $p < 0.05$.

Delay indicates delayed; immed, immediate; MINT, multilingual naming test; MoCA, Montreal Cognitive Assessment; UDS, Uniform Data Set; EAS, Einstein Aging Study.

Table 4B

Multiple linear regression coefficients estimates and 95% confidence intervals (CI) for sex, age, education, and race/ethnicity in the NACC sample

UDS Version 3 Neuropsychological Test**	NACC Sample			
	Female	Age (y)	Education (y)	Non-Hispanic Black
	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)	Coefficient (95% CI)
MoCA, total score	0.69 (0.50, 0.87) *	−0.10 (−0.12, −0.09) *	0.27 (0.24, 0.30) *	−2.75 (−3.00, −2.51) *
Craft Story 21 recall immed. verbatim, total units	1.45 (1.01, 1.89) *	−0.21 (−0.24, −0.17) *	0.31 (0.23, 0.39) *	−2.41 (−3.00, −1.82) *
Craft Story 21 recall immed. paraphrase, total units	0.91 (0.64, 1.18) *	−0.13 (−0.15, −0.11) *	0.21 (0.16, 0.26) *	−1.89 (−2.25, −1.54) *
Craft Story 21 recall delay. verbatim, total units	1.61 (1.17, 2.06) *	−0.23 (−0.26, −0.19) *	0.31 (0.23, 0.40) *	−3.11 (−3.71, −2.51) *
Craft Story 21 recall delay. paraphrase, total units	1.06 (0.78, 1.35) *	−0.15 (−0.17, −0.13) *	0.24 (0.19, 0.30) *	−2.38 (−2.77, −2.00) *
Benson complex figure copy, total score	0.20 (0.11, 0.29) *	−0.02 (−0.03, −0.01) *	0.07 (0.05, 0.08) *	−0.61 (−0.74, −0.49) *
Benson complex figure recall, total score	−0.16 (−0.35, 0.03)	−0.11 (−0.12, −0.09) *	0.13 (0.10, 0.17) *	−1.08 (−1.34, −0.82) *
Number span test forward, total correct trials	−0.19 (−0.35, −0.04) *	−0.03 (−0.04, −0.02) *	0.12 (0.09, 0.14) *	−0.73 (−0.94, −0.53) *
Number span test backward, total correct trials	0.03 (−0.12, 0.17)	−0.04 (−0.05, −0.03) *	0.12 (0.10, 0.15) *	−1.09 (−1.29, −0.90) *
MINT, total score	−0.83 (−0.98, −0.68) *	−0.07 (−0.08, −0.05) *	0.11 (0.08, 0.14) *	−2.54 (−2.74, −2.34) *
F-words, total in 60 s	0.97 (0.69, 1.25) *	−0.04 (−0.06, −0.02) *	0.38 (0.32, 0.43) *	−1.78 (−2.16, −1.39) *
L-words, total in 60 s	0.91 (0.65, 1.18) *	−0.05 (−0.07, −0.03) *	0.38 (0.33, 0.43) *	−2.00 (−2.36, −1.64) *
Total F- and L-words	1.92 (1.42, 2.43) *	−0.09 (−0.13, −0.05) *	0.75 (0.66, 0.84) *	−3.74 (−4.43, −3.04) *
Animals, total in 60 s	0.70 (0.39, 1.02) *	−0.18 (−0.20, −0.15) *	0.43 (0.37, 0.49) *	−3.71 (−4.11, −3.30) *
Vegetables, total in 60 s	2.87 (2.63, 3.11) *	−0.12 (−0.13, −0.10) *	0.20 (0.15, 0.24) *	−1.43 (−1.75, −1.12) *
Trail Making Test Part A, time (s)	−0.92 (−1.73, −0.10) *	0.64 (0.58, 0.70) *	−0.61 (−0.76, −0.46) *	10.67 (9.62, 11.73) *
Trail Making Test Part B, time (s)	−2.77 (−5.60, 0.06)	2.14 (1.92, 2.36) *	−3.30 (−3.82, −2.79) *	42.84 (39.15, 46.52) *

** Higher scores indicate better scores except for the Trail Making Test Parts A & B.

* indicates statistical significance at $p < 0.05$.

Delay indicates delayed; immed, immediate; MINT, multilingual naming test; MoCA, Montreal Cognitive Assessment; UDS, Uniform Data Set; NACC, National Alzheimer's Coordinating Center.