The Neuropsychological Performance of Nondemented Puerto Rican Nonagenarians

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Key Words

Successful cognitive aging • Puerto Rican nonagenarians • Oldest old population

Puerto Rican nonagenarians in the CERAD battery does not differ from the performance of US English-speaking nonagenarians.

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Abstract

Background/Aims: While the oldest old are the fastest growing segment of the US population, normative neuropsychological data for nondemented oldest old Spanish speakers are nonexistent. This study sought to evaluate the neuropsychological performance of nondemented nonagenarians residing in Puerto Rico and to compare their results with those of a similar English-speaking sample from New York. **Methods:** We studied 81 subjects who had a complete CERAD neuropsychological assessment in Spanish. We used multiple regression analysis to predict performance on the CERAD battery and ANCOVA to compare the Puerto Rico and New York samples. **Results:** In 10 out of the 13 neuropsychological tests administered, education was a significant predictor of performance. There were significant differences between the Puerto Rico and New York groups only in the Trail Making Tests. **Conclusions:** In this Puerto Rican sample, education was the strongest predictor of neuropsychological performance, which is consistent with previous studies. When education level is properly accounted for, the performance of

Introduction

The oldest old, those individuals aged 85 years and older, are the fastest growing segment of the US population. In spite of the vast amount of neuropsychological and cognitive research that has been conducted in the elderly population over the last two decades, very little is known about the changes in brain function that normally take place in this group. It is important to distinguish normal aging-related changes from disease in this group in order to detect disease in its earliest stages, when treatments can be most beneficial, and to find ways to maintain function as long as possible [1]. Among the nondemented oldest old, those aged 90 years and above are of special interest since in several studies of protective factors for dementia their first-degree relatives have been observed to have a reduced risk of Alzheimer's disease in comparison to relatives of younger, nondemented elderly [2, 3].

Table 1. Age and education descriptive statistics, distribution per sex and significance of comparisons between Puerto Rico and New York complete samples

	Puerto Rico	New York	p value for t or χ^2 test
Subjects, n	81	62	–
Age, years	92.82 $\pm$ 2.27	92.75 $\pm$ 2.52	0.712
Education, years	8.87 $\pm$ 5.21	15.76 $\pm$ 3.10	0.000
Female, %	57.3	64.5	0.396

While cognitive functioning in the oldest old is understudied in mainland US Caucasian populations, even less is known about this age group among the growing number of oldest old individuals of Hispanic origin. Hispanics represent 35.3 million, or about 12.5%, of the 281.4 million US Americans counted in the Census 2000, a 58% increase from 1990. For the year 2050, it is estimated that there will be 98.2 million Hispanics in the United States, accounting for 24.3% of the population. Of these, 13.4 million will be over 65 years of age. It is important to note that over 40% of Hispanics aged 65 years and over in Census 2000 said they spoke English ‘not well’ (20.99%) or ‘not at all’ (19.37%) so neuropsychological normative data for Spanish-speaking elderly are urgently needed. In fact, the US Alzheimer’s Association has concluded that ‘there are significant information and data deficits about ethnic and cultural groups in most major research areas in Alzheimer’s disease, including screening and neuropsychological testing instruments’ [4]. The lack of normative data for this important minority group may contribute to the misdiagnosis of cognitive function in research and clinical settings [5].

The CERAD neuropsychological battery has shown clinical utility in differentiating Alzheimer’s disease patients from nondemented controls in many countries [6–9], but norms for nondemented elderly are scarce, especially for nondemented oldest old, and nonexistent for oldest old Spanish speakers.

This paper examines neuropsychological data in nondemented nonagenarians in Puerto Rico, the vast majority of them community dwellers. The impact of age, education and sex on neuropsychological performance is examined in this sample. Comparisons are made with results obtained by a sample of Caucasian English-speaking nondemented nonagenarians from the Metropolitan New York area.

Materials and Methods

Puerto Rico Sample

The original Puerto Rico sample consisted of 81 Spanish-speaking nondemented nonagenarians [Clinical Dementia Rating Scale (CDR) score = 0; age range 90.07–98.65 years; table 1]. Subjects were recruited by the first author in all the Senior Centers, Independent Living Centers for the elderly and private and public agencies in Puerto Rico that serve the elderly population that were visited and agreed to collaborate with this study. No agencies or institutions were specifically targeted or discarded because of the characteristics of their residents or participants. Additionally, community-dwelling subjects were recruited by word of mouth among relatives and friends of participants already enrolled in the study and employees and staff of the agencies that were visited. All participants chose to be interviewed at the site where they were recruited. At the time of recruitment, all subjects signed a consent form approved by both the University of Puerto Rico Medical Sciences Campus Institutional Review Board and the Mount Sinai School of Medicine (MSSM) Institutional Review Board.

New York Sample

The original New York sample consisted of 196 volunteers participating in a research project based at the MSSM and the James J. Peters VA Medical Center in Bronx, N.Y., investigating cardiovascular risk factors in the oldest old. Subjects were recruited after talks on memory at senior centers in the tri-state area (New York, New Jersey, and Connecticut), the Bronx VA, or through newspaper ads. Only subjects who were at least 85 years old with a score of 0 (nondemented) on the CDR were included in that study. For comparison here we selected that subset of subjects that was aged 90 and above when tested ($n = 62$; 40 were women; table 1). The age range of this New York sample was 90.00–100.65 years. Because the number of enrolled African-American and Hispanic subjects was too small at the time of data analysis to support normative inferences, only the normative data for the White subjects were included. Eighty-eight percent of the participants were born in the USA and the rest had lived in the USA since early childhood. All of them spoke English as their first language.

Table 1 shows that the samples did not differ significantly in the age or sex distribution, but the New York sample did have a significantly higher level of education.

Assessment of Dementia

The primary criterion for absence of dementia was a global score of 0 on the CDR. On the CDR, clinical information is collected from the subject and from a knowledgeable informant relating to the subject’s memory, judgment, orientation, home and hobbies, community affairs, and personal care. Each of these domains is rated from 0 (no dementia) to 3 (severe dementia). The global score is computed through an algorithm devised by the authors of the scale [10]. The CDR raters (J.C.-B. and J.M.-C.) successfully completed the online CDR training modules offered by the Washington University Alzheimer’s Disease Research Center (ADRC) and were trained and supervised by Senior Neuropsychologists from the MSSM ADRC. While subjects with a CDR score of 0.5 or greater were automatically excluded from the sample, in addition, we were strongly conservative in our clinical

judgment with CDR 0s which were always based on the information collected from both the subject and the informant(s), as well as on our personal observations. If we had any doubts regarding the absence of dementia in a subject, we did not include him/her in our sample.

Neuropsychological Evaluation

Neuropsychological assessments were also conducted by psychologists trained and supervised by Senior Neuropsychologists of the MSSM ADRC. The neuropsychological evaluation used mainly tests from the Spanish version of the CERAD battery [11], which has been applied extensively in the diagnosis of dementia. Minor changes were made to the instruments in order to adapt them to the local culture. For example, one of the items to be named in the Boston Naming Test is a harmonica. While the accepted answer for harmonica in the standard Spanish version of the Boston Naming Test is *armónica*, we also accepted *sinfonía* as a valid answer since that is the word most Puerto Rican elders use to refer to a harmonica. These instruments have been used successfully with the Spanish-speaking participants at the MSSM ADRC and in pilot aging-related studies in Puerto Rico. A recent study in Colombia confirmed the validity and reliability of the Spanish version of the CERAD with local adaptations [12]. The following functions were assessed.

Mini Mental State Examination

This is a general cognitive screening test that measures orientation, language, concentration, constructional praxis, and memory [13]. The maximum score on the test is 30.

Verbal Memory

We used the Word List Memory (trial 1, trial 2, trial 3, total trials 1–3; 10-item word list). This is a free-recall memory test that assesses learning ability for new verbal information. On each trial, the 10 words are presented to the participant, each typed on a separate index card, in a different order. To make the test suitable for subjects with limited literacy, the evaluator says each word aloud while the cards are being presented to the subject. To ensure comprehension, the subject is then instructed to read aloud each word after it is presented. Immediately following each trial, the subject is asked to recall as many items as possible. The maximum score on each trial is 10. The maximum total score is 30.

Naming and Language

We used the Boston Naming Test. The purpose of this test is to assess the ability to name 15 black-and-white line drawings representing a range of high- to low-frequency words [14]. Maximum score is 15.

Category Fluency

Subjects were asked to generate exemplars in the animals category; 60 s were allowed. The total number of unique words was used for analysis.

Delayed Recall

We used the Delayed Word List Recall. This test assesses the ability to recall, after 15 min, the 10 words given in the Word List Memory Test. The maximum number of correct responses is 10.

Savings

The savings variable of the CERAD battery was created in order to access the number of words remembered. It is calculated by dividing the number of words remembered in the Delayed Recall of the Word List test by the number of words remembered in the third trial of the Immediate Word List Recall [11].

Word List Recognition

This test assesses recognition of the words from the Word List Memory Task when presented among 10 distracter words. The maximum score for correct recognition of the targets is 10. The maximum score for correct discrimination of the distracters is also 10.

Constructional Praxis

Four line drawings of increasing complexity are presented and the subject is asked to reproduce each on the same page. The maximum possible score is 11.

Since the CERAD neuropsychological battery lacks speed and flexibility components we also conducted the Trail Making Tests.

Trail Making Tests

The Trail Making Tests measure timed attention, mental flexibility and sequencing. Part A (Trails A) entails connecting randomly ordered numbers by drawing a line in sequence and has a strong motor speed and agility component. Part B (Trails B) entails connecting numbers and letters in alternating order and has a strong complex visual scanning component. Participants were allowed a maximum of 5 min for each test. The times to complete each of the tasks were used as the two measures for analyses.

Global cognitive and neuropsychological testing administration procedures were identical for the Puerto Rico and New York samples.

Statistical Analysis

Descriptive statistics were obtained for all the CERAD subtests as well as the Trails tests. The impact of education, age and sex on neuropsychological scores was determined through a multiple regression analysis. The comparison between the Puerto Rico and New York samples was conducted using an ANCOVA test.

Results

The Puerto Rico sample consisted of 81 subjects. No differences were found between the average ages of men versus women (92.99 for women, 92.85 for men, $p = 0.808$). Also, while women had almost 2 more years of education on average than men (9.87 ± 5.27 vs. 7.74 ± 4.78 years), this difference did not reach statistical significance ($p = 0.065$).

An initial inspection of the descriptive statistics of the neuropsychological tests revealed that 9 subjects (8 from Puerto Rico and 1 from New York) had obtained scores of 0 in either the first trial or in the Delayed Recall Tasks

Table 2. Neuropsychological test scores for the Puerto Rico sample

Battery subtest	Sub- jects	Mean	SD	Min.	Max.
MMSE total score	73	27.25	2.27	22	30
Fluency, animals	73	14.37	3.94	7	26
Trails A time, s	59	155.22	66.52	44	300
Trails B time, s	40	264.83	57.43	134	300
Word List Trial 1	73	3.73	1.41	1	7
Word List Trial 2	73	5.53	1.63	2	9
Word List Trial 3	73	6.64	1.72	4	10
Word List Trials 1–3 total	73	15.90	4.23	9	25
Word List Delayed Recall	73	4.60	2.11	1	9
Savings	73	68.56	24.09	16.67	125.00
Word List Recognition	73	18.48	1.63	12	20
Praxis	71	8.18	1.95	2	11
Boston Naming Test	73	12.22	1.84	7	15

Table 3. Magnitude and significance of association of education, sex and age with test scores in the Puerto Rico sample

Battery subtest	Sub- jects	Educa- tion β	Age β	Sex β
MMSE total score	73	0.491***	-0.197	0.000
Fluency, animals	71	0.182	-0.172	-0.170
Trails A time, s	56	-0.414*	0.091	-0.008
Trails B time, s	38	-0.381	0.003	0.088
Word List Trial 1	67	0.360*	-0.031	0.011
Word List Trial 2	67	0.364*	-0.028	0.049
Word List Trial 3	67	0.340*	-0.142	0.153
Word List Trials 1–3 total	67	0.398**	-0.079	0.085
Word List Delayed Recall	67	0.346*	-0.175	-0.039
Savings	67	0.246	-0.137	-0.221
Word List Recognition	67	0.460***	-0.076	-0.171
Praxis	66	0.376*	0.067	-0.200
Boston Naming Test	67	0.499***	-0.036	-0.264

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

of the CERAD Word List, which might be an indicator of a certain degree of cognitive impairment. To further ensure that the results reported in this study corresponded to a cognitively healthy sample, we excluded these 9 subjects of all subsequent analyses. This left 73 subjects in the Puerto Rico sample and 61 in the New York sample. Table 2 presents descriptive statistics for each of the neuropsychological tests, along with the number of subjects who completed each test. Due to vision or literacy limitations 14 subjects did not complete the Trails A test and 33

subjects did not complete the Trails B test. Some of the subjects with vision limitations were able to complete the Trails A test without major difficulties, but had problems distinguishing specific letters from numbers in the Trails B test (distinguishing the number '1' from the letter 'I' and the number '8' from the letter 'B' were two of the most challenging tasks for some). Most of the subjects with literacy limitations could identify the letters on the paper but could not recall the sequence of the letters in the alphabet so they quit the task shortly after getting started.

Table 3 presents, for each of the neuropsychological tests, the number of subjects who completed the test and the standardized multiple regression coefficients (β) for education, age and sex with their significance levels in our sample. This table also shows the significance levels (0.05, 0.01 or 0.001) for each coefficient and each test after adjustment for multiple comparisons using the Bonferroni-Holm procedure. The correlation between test performance and education was significant in all the tests except for Category Fluency, Trails B and Savings. After adjusting for multiple comparisons, age and sex were not significantly associated with any of the tests.

Since education was so highly correlated with test scores we proceeded to break our sample into 3 education levels and studied the groups separately. We chose to use 6 years as the cutoff point between low and medium education levels because in the early and middle 20th century in Puerto Rico many rural areas had schools that went up only to the 6th grade and where all students were frequently clustered in a single classroom. It is likely that the quality of the education provided by those schools was not comparable to that of other schools equipped with better facilities and resources. We also split the low education group by the Mini Mental State Examination (MMSE) score ('less than' and 'equal to or greater than' 25). This way, we are able to provide separate normative data for low-education nonagenarians with normal, or higher, MMSE scores (probably higher-functioning individuals who learned to read and write on their own or on the job) and for low-education nonagenarians with lower MMSE scores (probably lower-functioning individuals who never learned to read or write, who worked mostly in agriculture or unskilled jobs but proved to be nondemented, nonetheless). Table 4 presents, for each of the neuropsychological tests, and for each education level, the number of subjects who completed the test, along with the mean and standard deviation scores. As expected, with the exception of the Category Fluency Test, in all tests better scores are associated with a higher education level. Within the low-education group, subjects with

Table 4. Neuropsychological test scores by education level of the Puerto Rico sample

Battery subtest	Low education (0–6 years) MMSE score ≤ 24			Low education (0–6 years) MMSE score ≥ 25			Medium education (7–12 years)			High education (>12 years)		
	sub- jects	mean	SD	sub- jects	mean	SD	sub- jects	mean	SD	sub- jects	mean	SD
MMSE total score	7	23.00	0.816	16	27.38	1.668	31	27.23	2.045	19	28.74	1.327
Fluency, animals	7	13.86	2.610	16	15.06	5.013	31	13.42	3.757	19	15.53	3.454
Trails A time, s	4	213.75	79.51	11	186.45	67.42	28	157.14	60.04	16	115.75	55.04
Trails B time, s	3	300.00	0.00	5	296.00	8.94	17	273.82	49.17	15	237.20	69.83
Word List Trial 1	7	2.86	0.900	16	3.38	1.204	31	3.68	1.536	19	4.42	1.261
Word List Trial 2	7	4.86	1.069	16	5.00	1.673	31	5.42	1.544	19	6.42	1.644
Word List Trial 3	7	5.57	1.512	16	6.25	1.528	31	6.42	1.728	19	7.74	1.485
Word List Trials 1–3	7	13.29	2.690	16	14.63	3.793	31	15.52	4.304	19	18.58	3.791
Word List Delayed Recall	7	2.29	1.113	16	4.25	1.983	31	4.61	2.076	19	5.74	1.851
Savings	7	42.075	19.77	16	66.444	20.70	31	71.549	24.38	19	75.221	22.46
Word List Recognition	7	16.57	2.299	16	18.19	1.515	31	18.55	1.48	19	19.32	1.003
Praxis	6	6.67	1.033	16	7.50	2.033	30	8.50	1.834	19	8.74	1.996
Boston Naming Test	7	11.71	1.799	16	10.31	1.621	31	12.97	1.278	19	12.79	1.718

higher MMSE scores performed better in most tests than those with lower MMSE scores. While the differences between the mean scores of these two subgroups may appear small to the naked eye, and they are undetectable to an ANOVA, it is important to note that this is probably due to the small sizes of these two subgroups ($n = 7$ for the lower MMSE subgroup and $n = 16$ for the higher MMSE subgroup). Still, according to Cohen's classification system [15], the effect sizes for the differences between these two subgroups were either medium or large for all the battery subtests except for two of them (Word List Trial 2, $d = 0.100$; Fluency, $d = 0.300$).

Comparison of Puerto Rico and New York Samples

A final objective of this paper was to compare the performance of the Puerto Rico sample on the CERAD battery with that of a similar New York sample. New York data were collected and have been published previously [16]. Table 1 shows that the New York sample had a significantly higher level of education. For comparison purposes we excluded the Puerto Rican subjects in the low-education group because we had no subjects in the New York sample with fewer than 8 years of education. This left 50 subjects in the Puerto Rico sample. We compared the two samples with an ANCOVA, using the site variable (New York vs. Puerto Rico) as the main factor and sex (male vs. female) and education (in years) as covariates.

When the New York and Puerto Rico groups were compared with ANOVA (results not shown), there were significant differences between them in most tests. However, after controlling for sex and education using ANCOVA, there were significant differences between them only in Trails A and B (with better scores for the New York sample; table 5). After adjusting for multiple comparisons with the Bonferroni-Holm procedure, neither education nor sex were significant covariates in any of the tests.

Discussion

To our knowledge this is the first report of neuropsychological data on Spanish-speaking nondemented nonagenarians, and more specifically on nonagenarians living in Puerto Rico. Testing was conducted in Spanish and virtually all subjects were able to complete verbal memory testing using standardized word list recall with no evidence of floor effect. This is particularly important as verbal memory is the function most commonly used to assess cognition in the elderly. These participants were also able to complete tests such as naming, fluency and praxis with little difficulty. Executive function, another important cognitive domain in aging, was more difficult to assess because of the vision and literacy limitations of some of our subjects. While the low level of education of part of the sample poses challenges in terms of the inter-

Table 5. Mean test scores for Puerto Rico and New York sites and significance of ANCOVA factor effects

Battery subtest	New York		Puerto Rico		Site factor p	Sex p	Education p
	subjects	mean	subjects	mean			
MMSE total score	58	27.79	50	27.88	0.162	0.353	0.024
Fluency, animals	59	14.19	49	14.18	0.174	0.540	0.004
Trails A time, s	57	74.49	43	138.46	0.000***	0.901	0.764
Trails B time, s	55	180.62	31	255.26	0.000***	0.008	0.677
Word List Trial 1	61	4.67	49	3.94	0.343	0.136	0.012
Word List Trial 2	61	6.66	49	5.78	0.214	0.340	0.008
Word List Trial 3	59	7.71	49	6.86	0.127	0.017	0.043
Word List 1–3 total	59	19.02	49	16.57	0.169	0.065	0.004
Word List Delayed Recall	60	6.03	49	5.00	0.078	0.565	0.150
Savings	59	77.62	49	73.00	0.455	0.151	0.494
Word List Recognition	60	19.36	49	18.72	0.548	0.764	0.008
Praxis	57	9.38	48	8.75	0.351	0.197	0.069
Boston Naming Test	58	13.19	49	12.94	0.950	0.022	0.063

*** $p < 0.001$.

pretation of the complete data set, it also provides an opportunity to assess the performance of a very important segment of the Puerto Rican nonagenarian population – those with little or no formal schooling – and furnish neuropsychological test norms specific to this group. This segment of the population is very important among US mainland residents as well: according to Census 2000, more than 62% of US Hispanics aged 85 and over have less than a 9th grade education. Our further segmentation of the low-education group into subjects with higher and lower MMSE scores – and the differences observed in most test scores between these two groups – suggests the existence of two distinct subgroups among the low-education group (higher and lower function) and provides additional information that might assist clinicians in their assessment of elders belonging to these two groups. Another strength of our study is that it is one of the few studies that have compared the neuropsychological performance of samples from different cultures and languages using exactly the same test battery and the same test administration and scoring procedures, with interviewers trained and assessed by the same supervisors.

Our results indicate that, among Spanish-speaking Puerto Rican nonagenarians, education is the strongest predictor of neuropsychological performance. This is consistent with findings from many other studies in several cultures [11, 17, 18] that have brought attention to the importance of education on neuropsychological perfor-

mance throughout the life span, even among oldest old subjects [16].

Several studies have reported performance differences by sex in most, if not all, of the CERAD tests in nondemented adults over 65 years of age [11, 17]. We wanted to determine if the sex effect is still present in nonagenarians. In this study, even though women had a marginally significantly higher level of education, we did not find a significant sex effect. In another study with oldest old subjects in New York, sex turned out to be the weakest predictor of neuropsychological performance [16]. It is possible that, in very old ages, the effect of sex on neuropsychological test scores is greatly diminished. In our sample, none of the test scores was associated with age. This is not surprising given the small range of ages included in our sample selection criteria.

Previous studies have reported significant differences in neuropsychological performance between English-speaking samples from different cultures in the United States [19] even after controlling for demographic variables such as age, education and sex [20]. These differences might be expected to be even more significant when comparing samples that speak different languages given that some neuropsychological concepts may not translate well into other languages. Indeed, one study found the performance of a Spanish-speaking sample in the USA to be significantly lower than an age- and education-matched sample of English speakers in the same battery of tests [21]. Therefore, we expected our sample of Span-

ish-speaking nondemented Puerto Rican nonagenarians to perform worse in the CERAD than a similar English-speaking sample. However, after controlling for sex and education, the performance of the Spanish-speaking sample was not different from that of the English-speaking sample with the exception of the Trail Making Tests.

The difference in Trails performance between the samples is not surprising: when the performance on the Trails by non-White samples is compared to the performance of the mostly non-Hispanic White samples used to obtain normative data, the non-White samples usually get worse scores [22, 23].

Our results are consistent with those of previous studies that have found that education is the most important predictor of neuropsychological performance, even among the oldest old. Our findings suggest that, when education level is properly accounted for, the performance of Spanish-speaking nondemented Puerto Rican nonagenarians in the CERAD battery does not differ from the performance of US Caucasian English-speaking nondemented nonagenarians.

A limitation of our study is that we have assumed that our population is nondemented based on a CDR score of

0, and there is a possibility that some subjects with a CDR score of 0 may present mild cognitive impairment [24]. However, our careful screening of the subjects in our study and the fact that we excluded all questionable cases adds to our confidence that the subjects included were cognitively intact when tested. By 'questionable cases' we mean cases where there were discrepancies between an informant's opinion and the subject's actual performance on the CDR, even when the case could not be classified as a 0.5 in the CDR. Another limitation of our study is that, similar to many other studies providing normative neuropsychological data in aged populations [7, 9, 22], our sample was not randomly selected from the population and therefore may not be representative of the Puerto Rican nonagenarian population.

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