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Neuropsychological Profile of a Group of Puerto Ricans with Alzheimer's Disease

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Abstract— Background: Alzheimer's Disease (AD) is the most common type of dementia up to date. AD is characterized by the progressive impairment of neurocognitive functions and behavioral manifestations that interfere with daily life. AD represents the fourth cause of death in Puerto Rico, highlighting the pressing need to identify neuropsychological profiles of the pathology in this population to promote early diagnosis and facilitate individualized neuropsychological rehabilitation. This study explored the demographics and neuropsychological performance of Puerto Ricans with AD to assess specific neurocognitive patterns that contribute to the identification, staging, and tracking of the progression of the disease. Methods: We completed a comprehensive neuropsychological evaluation to 95 Puerto Rican adults with AD aged 65 and older and compared results with the norms of a healthy Hispanic population. Results: Participants with AD showed poor verbal memory and learning followed by attention, language, verbal fluency, visuospatial and motor deficits. Additionally, having advanced age and low education achievement showed a significant negative impact on neurocognitive functioning. Conclusions: The pattern of the neurocognitive deficits shown in Puerto Ricans with AD are characteristic of a frontotemporal presentation of the AD. Understanding this pattern may allow early AD symptom detection and further neuropsychological rehabilitation.

***Keywords*:-** *Alzheimer's Disease, Neurocognitive Domains, Neuropsychological Profile, Puerto Rico.*

I. INTRODUCTION

Alzheimer's Disease (AD) is the most common type of dementia affecting the elderly population (Apostolova et al., 2012). AD is characterized by psychological, behavioral, and cognitive degeneration, slowly impairing the patient's memory, communication skills, and the capacity to carry out daily activities (Holmquist et al., 2007). AD arises from the formation of senile plaques and neurofibrillary tangles, resulting in loss of neurons (Mattson, 2004). AD prevalence raised to epidemic proportions, now leading the 6th cause of death in the United States (US) mainland, affecting 5.8 million Americans (Alzheimer's Association, 2019). In Puerto Rico, AD leads the 4th cause of death (Friedman et al., 2016), affecting 12.5% of the population (Departamento de Salud, 2015). Additionally, Figueroa et al. (2008) found that mortality rates associated with AD were higher in Puerto Ricans living in Puerto Rico, compared to those living in the US. The authors attributed these differences to factors, such as quality of health services, socioeconomic factors, genetics, and other aspects.

Numerous efforts have been focused on the clinical and neuropsychological study of AD, particularly in the US mainland, to identify the course and characteristics of the disease for greater histopathological understanding and development of specialized treatment. However, in Puerto Rico, most studies have been centered on assessing the somatic profile of patients with AD, but studies about their neuropsychological profile have been limited. Lack of studies investigating the neuropsychological aspects of patients with AD in Puerto Rico may be associated with the limited practice of neuropsychology in the island. According to Rodríguez-Irrizary et al. (2018), the discipline of neuropsychology, including the use of assessment tools for research and rehabilitation procedures, is extremely limited in Puerto Rico and only 59% of the individuals with training in neuropsychology (of 25 self-identified professionals that were included in a survey) were specialized in dementia. Moreover, besides the limited access of specialized services, studies suggest that several factors increase the risk for Latinos to develop AD, such as high blood pressure and obesity (eating patterns), which may affect the aging brain's ability to function effectively and could lead to diverse symptom manifestations (González-Rodríguez et al., 2016). Previous studies on AD in the Latino population has suggested that genetics, geographical region, and social context differences should also be considered, as they influence AD symptom manifestations and treatment response, as well as this population's ability to seek appropriate healthcare services (Vega et al., 2018). Furthermore, the high incidence of AD in Puerto Rico begs for adequate assessment with culturally relevant instruments and evidence-based treatment considering health disparities for the Hispanic population.

There is limited research on AD in Puerto Rico. The most recent efforts in the study of AD in Puerto Rico have been centered on mortality rates (Figueroa et al., 2008), demographic profiles and incidence on the island (Camacho-Mercado et al., 2016), education and awareness of the disease

in the population (Friedman et al., 2016), and genetic studies (Rajabli et al., 2018). Figueroa et al. (2008) compared the mortality rates of Puerto Ricans living on the island, Puerto Ricans living in the US, and Americans living in the US with AD and found that mortality rates of AD patients in Puerto Rico was higher than Puerto Rican patients living in the US.

Previous research has identified three common presentations of AD: (1) temporo-frontal, (2) temporo-parieto-frontal, and (3) posterior cortical atrophy. The temporo-frontal presentation of AD is characterized by loss of rapid memory ability and recent memory loss, followed by loss of verbal memory, including language, semantic or categorical verbal fluency, and executive dysfunction (Weiner & Lipton, 2009). In the temporo-parieto-frontal presentation, nonverbal memory is affected, particularly visuospatial abilities, visual construction, and orientation. The temporo-parieto-frontal presentation differs from the temporo-frontal presentation in that verbal memory is not affected during the initial stages of the disease. Finally, in the posterior cortical atrophy presentation of AD, the parietal and occipital lobes are initially deteriorated, affecting visual and spatial skills, including recognition, spatial processing, and visual attention.

Several studies have described the temporo-frontal presentation of AD. Ramirez-Gomez (2017) performed neuropsychological assessments to 69 participants with dementia, including AD. The participants with AD included in the study showed greater impairment in verbal memory and semantic verbal fluency; characteristic of the temporo-frontal presentation of AD. Another study showed the presence of semantic deficits in early AD and Parkinson's Disease (Guidi et al., 2015). Henry & Crawford (2004) also found in their meta-analysis more deficits in semantic fluency compared to phonemic fluency in AD patients, suggesting impairments in semantic memory storage. Moreover, Weintraub et al., (2012) reviewed the neuropsychological features of AD dementia in the US and how they differ from “normal”, age-related cognitive decline and other types of dementia. They indicated that AD commonly affects medial temporal lobe structures, circumscribed to the ability to learn, consolidate, and retrieve information. Various studies agree that episodic memory is initially affected in individuals with AD, as assessed by instruments that measure verbal memory (e.g., CERAD and CVLT) (Alves et al., 2012). According to these studies, impairments in episodic memory are related to degeneration of executive functions, leading attentional control, inhibition, problem solving, behavior, and working memory deficits (Alves et al., 2012; Chen et al., 2001).

Furthermore, other studies have found early deficits in nonverbal memory and visuospatial abilities (Johnson et al., 2009). These changes lead to viso-constructional, viso-perceptual, and orientation impairments (Weintraub et al., 2012). In their review, Weintraub et al. (2012) cite studies which found that participants with AD showed greater impairment in cortical regions that process visual components (e.g., color and shape), visual search, and divided attention of visual information (Festa et al., 2005). Thus, when initial impairments are greater in nonverbal memory, visuospatial and attentional abilities, temporo-parieto-frontal presentation may be the manifestation.

Moreover, Caine (2004) described a less common AD presentation: posterior cortical atrophy. Patients with posterior cortical atrophy show higher order visual dysfunction or marked early visual deficits, circumscribed to agnosia, constructional apraxia, simultagnosia, acalculia, right-left disorientation, finger agnosia, and agraphia (Weintraub et al., 2012). Impaired color perception, decreased visual attention, and decreased contrast sensitivity may also be present (Caine, 2004; Weintraub et al., 2012). However, memory functions, language, and judgment are usually preserved.

These findings show evidence of significant changes in the neuropsychological manifestations and the pathological profile of AD. For this reason, identifying the neuropsychological profiles of AD is crucial in understanding the disease and providing adequate, effective, individualized, and culturally competent evidence-based treatment.

Despite efforts to investigate AD in Puerto Rico, limited clinical profiles and no neuropsychological profiles have been described to distinguish presentations and progression of AD in Puerto Ricans. Therefore, the current study aimed to establish a clinical precedent for AD in Puerto Ricans living in the island in order to provide personalized treatment and rehabilitation recommendations during the preclinical stages of the disease and attempt to slow down the process of deterioration and degeneration. In other words, we aimed to describe the demographic characteristics and identify the neurocognitive domains that are impacted in a group of Puerto Ricans with AD. With these aims in mind, we addressed three fundamental questions: (1) What are the demographic characteristics of a group of Puerto Ricans with AD?, (2) Which neurocognitive domains are more affected by AD in a group of Puerto Rican patients?, and (3) What is the relationship between demographic characteristics and neurocognitive performance in Puerto Ricans with AD? Given the heterogeneity of the risk factors, such as genetics, hypertension, obesity (eating patterns), depression, geographical and social contexts, and lower education attainment, that makes Latinos more susceptible to develop AD, we hypothesized that Puerto Ricans would have a distinct neuropsychological profile.

II. METHOD

- *Research design*

This study has a cross-sectional design with a descriptive method. Cross-sectional studies are focused in describing the association of a specific subject in the present moment (Mann, 2003). These conditions defined the main purpose of this study, which is the description of demographic characteristics and the neuropsychological profile of a group of patients with AD in Puerto Rico.

- *Participants*

The study consisted of 95 participants diagnosed with AD. Participants were recruited from private clinics, elderly homes and outpatient care centers from different regions of

Puerto Rico. The inclusion criteria included: (1) Patients diagnosed with AD in any stage of severity and (2) with 65 years old and older. The exclusion criteria included: (1) Individuals with chronic psychopathology, history of brain injury and convulsions, (2) alcohol or drug use, (3) diagnosis of cerebrovascular accident (CVA) and (4) major neurological disorder. The sociodemographic characteristics of the participants are included in Table 1.

TABLE 1

Sociodemographic Variables	*N*	*M(SD)*	*%*
Age	-	80(7.9)	-
Gender			
Female	68	-	72
Male	27	-	28
Education (yrs)			
-	95	9.6 (5.3)	-
Language			
Spanish	67	-	65
Spanish & English	36	-	35
Handedness			
Right	93	-	97
Left	2	-	3

Sociodemographic Characteristics of the Participants with AD (n=95)

➢ ***Neuropsychological Tests***

Test of Nonverbal Intelligence, Fourth Edition (TONI-4). The TONI-4 is a language-free intelligence test, which measures intelligence, aptitude, abstract reasoning, and problem solving. The TONI-4 was standardized on a representative sample of 2,273 people of 33 states, aged between 6 and 89 years of age (Brown et al., 2010). Norms were stratified by gender, race, ethnicity, and geographic location and included Spanish-speaking individuals (Brown et al., 2010).

Escala de Inteligencia Wechsler para Adultos- Ed. III (Wechsler Adults Intelligence Scale, WAIS-III). We used the Block Design and Digit-Symbol Coding subtests of the Spanish adaptation and validation of the EIWA-III in Puerto Rico (Pons et al., 2008). The Block Design subtest measures the ability to discriminate abstract patterns in non-verbal reasoning and the Digit-Symbol Coding subtest measures viso-motor coordination, new learning in a visual context, and processing speed.

Addenbrooke's Cognitive Examination-Revised (ACE-R). The ACE-R is a brief cognitive screening battery that detects and classifies mild cognitive impairment and dementia (Nieto et al., 2016). It has high sensitivity (95.7%) and specificity (87.5%) in the detection of dementia (Larner & Mitchell, 2014). The duration of the test is approximately 20 minutes.

Color Trails Test I & II. The Color Trails Test emerged from the Trail Making Test, as it evaluates similar frontal and executive cognitive abilities. However, it was created in a broader cross-cultural application (Messinis et al., 2011). Only numbers and instructions can be given verbally or non-verbally and it has an approximate duration of 10 minutes.

Boston Naming Test-2 (BNT-2). The BNT-2 is a 30-item short version of the original Boston Naming Test and it evaluates visual naming ability with the use of black and white drawings of common objects (Strauss et al., 2006).

Hopkins Verbal Learning Test-Revised (HVLT- R). The HVLT-R is a short assessment of verbal learning and memory developed by Brandt and Benedict (2001). Norms were used from the standardization by Arango-Lasprilla et al. (2015).

NEUROPSI Breve: Semi-Complex Figure subtest. The Semi-Complex Figure subtest has standardized norms for several populations, including Latin American and Spanish-speaking populations (Ostrosky-Solís et al., 1999). It measures viso-motor abilities and recognition. This subtest was used because it has more sensibility to assess visuospatial abilities, compared to the Rey–Osterrieth Complex Figure, making it convenient to minimize fatigue and frustration in a cognitive impaired population (Ostrosky-Solís et al., 1999).

➢ ***Grooved Pegboard Test***

The Grooved Pegboard Test evaluates manipulative dexterity and complex visual-motor coordination. It consists of 25 holes with randomly positioned slots and pegs that must be rotated to match the whole before it is inserted (Ruff & Parker, 1993). We used the Model 32025 described by Reitan-Klove (1963) and the norms were published by Ruff & Parker (1993). The test has an approximate duration of 5 to 10 minutes.

➢ ***Lawton's Instrumental Activities of Daily Living (IADL)***

The IADL measures executive functions and everyday functioning. It consists of 8 items that are rated with a summary score from 0 (low functioning) to 8 (high functioning) (Barberger-Gateau et al., 1992). Norms are available for Hispanics living in the United States and in Latin America (Ferraro, 2002). It has a duration of 10 to 15 minutes (Lawton & Brody, 1969).

➢ ***Procedures***

This study was approved by the Institutional Review Board (Protocol Number: 170410JH) at Ponce Health Sciences University. After the recruitment of the participants, the informed consent was discussed, which included information about the purpose of the study, inclusion/exclusion criteria, the voluntary nature to participate in the study, and possible risks and benefits. No monetary compensation was given to the participants. Each participant underwent a standardized evaluation in Spanish, including an interview (sociodemographic, medication, and medical history inquiry) and a neuropsychological evaluation through a variety of neurocognitive measures. An interview with an informant (e.g., caregiver) was also conducted to inquire for functional difficulties. After all assessments were performed, the results were sent via mail to every participant of the study.

➢ ***Data Analysis***

The collection of data was analyzed with SPSS 21 (IBM) statistical software. Central tendencies measures were conducted to explore the demographic characteristics of the participants. To assess the neurocognitive performance of Puerto Rican participants with AD, One sample t-tests analyses were used to examine differences between the AD sample and the known population mean values of healthy Hispanics. Furthermore, we performed Pearson's correlations to observe the relationship between the demographic characteristics of the AD sample and their neuropsychological performance. We calculated the effect sizes of the correlations by using Cohen's d, to measure the differences between the mean values of the AD sample and the mean values of a healthy Hispanic population. In addition, an Independent samples t-test was performed to compare the neuropsychological performance of AD participants by gender.

III. RESULTS

➢ ***Descriptive Statistics***

The participants with AD (72% females) had a mean age of 80 (SD=7.9). The AD sample had a mean education level of 9.6 (SD=5.3) years. The demographic characteristics of the AD sample are shown on Table 1.

➢ ***Performance of the Participants by Neurocognitive Domains***

To determine which neurocognitive domains were more impaired in a group of Puerto Ricans with AD, we compared their performance with the known population mean of healthy Hispanics (see Table 2). A One sample t-test was conducted to compare the neurocognitive performance of the AD sample (n=95) and individuals without AD (norms of healthy Hispanic subjects).

TABLE 2.

Neuropsychological test	M(SD) AD Subjects	M(SD) Healthy Subjects	Healthy Hispanic Population (Studies)
TONI-4 *Form A*	15.12 (4.95)	26 (14)	Brown, et al., 2010
EIWA III- *Block Design* subtest	10.70 (6.26)	9.20 (2.98)	Olavarría-Rodríguez, 2003
EIWA III- *Digit Symbol Coding* subtest	19.35 (6.47)	9.10 (2.90)	Olavarría-Rodríguez, 2003
ACE-R	44.2 (21.06)	85.4 (8.18)	A. Nieto et al., 2016
Color Trails Test 1	158.71 (43.95)	62 (32)	D'Elia, et al., 1989
Color Trail Test 2	234.35 (42.32)	141.47 (48.46)	D'Elia, et al., 1989
Boston Naming Test (BNT)- *Short Version*	12.56 (5.45)	23.54 (3.07)	Pontón et al., 1996
Hopkins Verbal Learning Test (HVLT)- *Copy*	9.27 (4.21)	22 (5.0)	Arango-Lasprilla et al., 2015
Hopkins Verbal Learning Test (HVLT)- *Delay*	.67 (1.18)	7.5 (2.8)	Arango-Lasprilla et al., 2015
NEUROPSI Breve subtest: Semi-Complex Figure- *Copy*	6.7 (2.46)	7.5 (1.7)	Ostrosky-Solís et al., 1999
NEUROPSI Breve subtest: Semi Complex Figure- *Delay*	1.7 (2.17)	6.6 (2.6)	Ostrosky-Solís et al., 1999
Grooved Pegboard- *Dominant*	139 (18.54)	77.9 (11.55)	Ruff et al., 1993
Grooved Pegboard- *Non-Dominant*	152.14 (16.55)	85.2 (13.4)	Ruff et al., 1993

Comparison of Neuropsychological Test Scores Between the AD Sample (n=95) and the Hispanic Healthy Population

➢ ***Cognitive Screening***

Results showed statistically significant differences between the ACE-R test performance of the AD sample and the healthy Hispanic population t (94) = -19.06, p < .01. The quality of the difference was negative, suggesting that the sample with AD performed worse than healthy subjects. The effect size of the difference between groups in the ACE-R was large by one standard deviation (Cohen's d= 1.95).

➢ ***Intellectual Ability***

Results revealed statistically significant differences between the AD sample and the healthy Hispanic population in non-verbal intellectual abilities (See Table 2). Significant differences were observed between the AD sample and the healthy Hispanic population mean scores in the performance of the TONI-4, t (94) = -20.9, p < .01. The quality of the difference was negative, suggesting that the AD sample showed worse performance in the TONI-4 than healthy Hispanic subjects. The effect size of the difference between groups in the TONI-4 was large by two standard deviations (Cohen's d= -2.19). Significant differences were also observed between groups in the EIWA-Digit-Symbol Coding subtest; t (94) = 15.44, p < .01, where the AD sample performed worse than healthy Puerto Rican subjects. The effect size in the EIWA-Digit-Symbol Coding subtest was large by two standard deviations (Cohen's d= -1.56). Additionally, significant differences were observed between groups in the EIWA- Block Design subtest, t (94) = 3.36, p = .01, in which the AD sample showed improved performance compared to healthy Puerto Rican subjects, although, the effect size was small (Cohen's d= 0.23).

➢ ***Language***

Statistically significant differences were observed between the AD sample and healthy Hispanic subjects in several tests that measured language skills (See Table 2), including a test of confrontation naming, the BNT; t (94) = -19.62, p < .01. The quality of the difference between groups in this test was negative, suggesting that the AD sample performed worse than healthy Hispanic subjects. The effect size of the difference between groups in the BNT was large by two standard deviations (Cohen's d= -2.01).

➢ ***Memory***

There were statistically significant differences between the AD sample and healthy Hispanic population in the HVLT-Copy, t (94) = -30.60, p <.01, in the HVLT- Delay, t (94) = -56.2, p < .01, in the NEUROPSI Breve Semi-Complex Figure-Delay, t (94) = -21.97, p < .01. The quality of the differences was negative, suggesting that the AD sample performed worse in these tests than the healthy Hispanic population. The effect size of the difference between groups was large by two or more standard deviations in the HVLT- Copy (Cohen's d= -3.02), the HVLT- Delay (Cohen's d= -5.7) and the NEUROPSI Breve Semi-Complex Figure- Delay (Cohen's d= -2.67).

➢ ***Visual Spatial Functioning***

Statistically significant differences were observed between the AD sample and healthy Hispanic subjects in the NEUROPSI Breve Semi-Complex Figure- Copy, t (94) = -3.11, p < .05. The quality of the difference was negative, suggesting that the AD sample performed worse than healthy Hispanic subjects in this test, although the effect size was small (Cohen's d=.04).

➢ ***Attention, Executive Functions, and Motor Skills***

Statistically significant differences were observed between the AD sample and healthy Hispanic subjects in the performance of the Color Trails Test 1, t (94) = 21.44, p < .01, in the Color Trails Test 2, t (94) = 21.38, p < .01, the Grooved Pegboard- Dominant; t (95) = 32.10, p < .01, and Grooved Pegboard- Non-Dominant; t (95) = 39.40, p < .01. The participants with AD took considerably more time to complete the Grooved Pegboard Test and Color Trails Test 1 & 2 than healthy Hispanic subjects, suggesting that processing speed may be impaired in the subjects with AD. The effect size was large by two or more standard deviations in the Color Trails Test 1 (Cohen's d= -2.18), Color Trails Test 2 (Cohen's d= -2.19), Grooved Pegboard- Dominant (Cohen's d= -3.29), and Grooved Pegboard- Non-Dominant (Cohen's d= -4.04).

❖ ***Relationship between Demographic Characteristics and Neuropsychological Performance***

➢ ***Age and Neuropsychological Performance***

Pearson Correlations showed a positive and significant relationship between age and the performance of the participants with AD in the Color Trails Test 1, r (95) = .23, p < .05, Semi-Complex Figure- Delay, r (95) = -.23, p < .05, DLA's, r (95) = -.32, p = < .01, and the MMSE, r (95) = .19, p = .05. The Color Trails Test 1 & 2 showed a positive and significant relationship with age. However, the MMSE had no discernable increasing or decreasing linear pattern and the magnitude of the association with age was weak. The Semi-Complex Figure- Copy showed a negative and significant relationship with age. However, DLA's showed a negative moderate correlation with age. The interaction (estimated means) between age and the neuropsychological performance of Puerto Ricans with AD is found on Table 3.

TABLE 3

Test	*r*	*p*	Direction of Linear Relationship (increasing, decreasing)	Strength of Linear Relationship (weak, moderate, strong)
TONI-4	-.16	.10	x	x
EIWA-III-Block Design	.00	.96	x	x
EIWA-III-Digit Symbol-Coding	-1.1	.16	x	x
MMSE	-.19	.05	Negative relationship/ - decreasing	Weak
ACE-R	-.16	.11	x	x
Color Trails Test 1	.23*	.02	Positive relationship/ + increasing	Weak
Color Trails Test 2	-.02	.81	x	x
BNT- Short Version	-.00	.96	x	x
HVLT- Copy	-.10	.30	x	x
HVLT- Delay	-.12	.24	x	x
Semi-Complex Figure- Delay	-.23	.02	Negative relationship/ - decreasing	Weak
Semi-Complex Figure- Copy	-.18	.06	x	x
Grooved Pegboard-Dominant	.07	.45	x	x
Grooved Pegboard- Non-Dominant	.09	.35	x	x
PHQ-9	-.01	.87	x	x
BAI	-.15	.14	x	x
DLA's	-.32**	.00	Negative relationship/ - decreasing	Moderate

Note. TONI-4=Test of Non-Verbal Intelligence, MMSE=Mini Mental Status Examination, BNT=Boston Naming Test, HVLT=Hopkins Verbal Learning Test, PHQ-9=Patient Health Questionnaire-9, BAI=Beck Anxiety Inventory, DLA's=Daily Living Activities. Block Design and Digit Symbol-Coding are subtests of the Wechsler Intelligence Scale for Adults, Third Edition/Spanish Version (EIWA-III). x= No relationship was observed. * Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed) a Pearson's correlation coefficient (r).

➢ ***Education and Neuropsychological Performance***

Results revealed positive and statistically significant relationships between education and the neuropsychological performance of subjects with AD. EIWA-III subtests Block Design, r (95) = .50, p < .01 and Digit-Symbol Coding, r (95) = .49, p < .01 showed a positive and strong correlation with education, suggesting that the higher the education level, the better intellectual performance. The neurocognitive screenings MMSE, r (95) = .35, p < .01 and the ACE-R, r (95) = .34, p < .01, as well as the HVLT-Delay, r (95) = .38, p < .01 showed a significant relationship with education. The direction of the linear relationship was positive and the strength was moderate. Finally, the Color Trails Test 1, r (95) = .23, p < .05, the Color Trails Test 2, r (95) = .27, p < .01, and the HVLT- Copy, r (95) = .28, p < .01 showed a significant relationship with education and a positive linear direction with weak strength correlation. Findings on the relationship between education and neuropsychological performance is shown on Table 4.

TABLE 4

Test	*r*	*p*	Direction of Linear Relationship (increasing, decreasing)	Strength of Linear Relationship (weak, moderate, strong)
TONI-4	.35**	.77	x	x
EIWA-III- Block Design	.34**	.01	Positive relationship/ + increasing	Strong
EIWA-III- Digit-Symbol Coding	.03	.01	Positive relationship/ + increasing	Strong
MMSE	.50	.01	Positive relationship/ + increasing	Moderate
ACE-R	.49	.01	Positive relationship/ + increasing	Moderate
Color Trails Test 1	.23*	.05	Positive relationship/ + increasing	Weak
Color Trails Test 2	.27**	.01	Positive relationship/ + increasing	Weak
BNT- *Short Version*	.16	.10	x	x
HVLT- *Copy*	.28	.01	Positive relationship/ + increasing	Weak
HVLT- *Delay*	.38	.01	Positive relationship/ + increasing	Moderate
Semi-Complex Figure- *Delay*	.39	.71	x	x
Semi-Complex Figure- *Copy*	-.22	.02	x	x
Pegboard Dynamometer- *Dominant*	-.11	.28	x	x
Pegboard Dynamometer- *Non-Dominant*	-.16	.11	x	x
PHQ-9	-.14	.18	x	x
BAI	-.16	.10	x	x
DLA's	.07	.49	x	x

Note. TONI-4=Test of Non-Verbal Intelligence, MMSE=Mini Mental Status Examination, BNT=Boston Naming Test, HVLT=Hopkins Verbal Learning Test, PHQ-9=Patient Health Questionnaire-9, BAI=Beck Anxiety Inventory, DLA's=Daily Living Activities, Block Design and Digit Symbol-Coding are subtests of the Wechsler Intelligence Scale for Adults, Third Edition/Spanish Version (EIWA-III).
* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed) a Pearson's correlation coefficient (r).

➢ *Gender and Neuropsychological Performance*

There were no statistically significant relationships between gender and the neuropsychological performance of the participants with AD in all the neuropsychological tests ($p > 0.05$). An Independent samples *t*-test was performed to compare the neuropsychological performance of the AD sample by gender (females vs. males). Results showed no significant differences between females and males in their performance during all neuropsychological measures ($p > 0.05$).

IV. DISCUSSION

The current study aimed to identify and describe the neuropsychological profile of a group of Puerto Ricans with AD living in the island. Neuropsychological assessments are fundamental in identifying and monitoring neurocognitive changes associated with neurological and psychiatric diseases and play a vital role in determining the extent and quality of AD presentations. The results of this study revealed severe deficits, circumscribed to verbal memory and learning, attention, language, and verbal fluency and moderate impairments in visuospatial abilities and motor skills in participants with AD, compared to the healthy Hispanic population. This pattern of deficits is characteristic of the temporo-frontal presentation of AD. Participants with AD showed the worst performance in neuropsychological tests that measured auditory attention, auditory memory/verbal memory, expressive language, vocabulary (HVLT), manual dexterity speed, bimanual coordination, sequencing ability (Grooved Pegboard Test), divided attention, visuomotor tracking, cognitive flexibility, shifting, inhibition, and working memory (Color Trails Test 1 & 2). However, less severe deficits were observed in visual organization of conceptual image, visual-spatial constructional ability, visual perception and non-verbal memory (Semi-Complex Figure), processing speed, 3D visual-constructional skills, visuospatial organization, problem-solving ability, motor coordination and impulsivity (EIWA-III- Block Design subtest), and visual scanning, shifting, motor persistence, sustained attention, processing speed, visuomotor coordination and perceptual organization (EIWA-III- Digit-Symbol Coding). This temporo-frontal presentation of AD suggests significant encoding, consolidation, and retrieval of verbal memory and frontotemporal cortical involvement. Furthermore, the extent of motor impairments earlier in the development of AD may be explained by the interconnection of cortical and subcortical regions associated to motor control systems that

regulate initiation, planning, and executive motor functions, given that motor functioning is not a unitary process (Buchman & Bennet, 2011).

These findings are congruent with other studies where a temporo-frontal presentation of AD is notable and characterized by early verbal memory impairments and frontal deficits and late impairments in visuospatial and motor abilities (Weiner & Lipton, 2009). Greenaway et al. (2006) explored the patterns of memory dysfunction in individuals with amnestic mild cognitive impairment (MCI), individuals with AD, and cognitively intact subjects (i.e., normal aging sample) using the California Verbal Learning Test (CVLT). They found that MCI subjects performed better than AD subjects but worse than the normal aging sample, showing reduced learning, rapid forgetting, recency recall effect, intrusion errors, and poor recognition discriminability, which are characteristic of AD.

These findings suggest verbal memory deficits in individuals with MCI, supporting the view of MCI as a preclinical stage and the temporo-frontal presentation of AD; the latter was also observed in the results of the present study. Similarly, Teng et al. (2013) performed a neuropsychological battery to assess memory, attention, language, visuospatial, and executive functioning in participants with amnestic MCI, with non-amnestic MCI, and with AD. Their results showed greater deficits in semantic fluency, compared to phonemic fluency, in amnestic MCI participants, compared to non-amnestic MCI, which was similar to the pattern observed in participants with mild AD. The authors suggest that poor performance on semantic verbal fluency tasks in AD are often present in the early stages of the disease and lead to greater changes in the temporal lobe, which is also supported by neuroimaging studies (Dos Santos et al., 2011). However, these results are in contrast with other studies that suggest that the involvement of frontal cerebral areas in AD is linked to rather advanced phases of the disease (Braak & Braak, 1991). Weissberger et al. (2019) assessed the patterns of neuropsychological deficits in Hispanic and Non-Hispanic patients with autopsy-confirmed AD and found increased impairments in memory, compared to deficits in language, attention, executive functions, and visuospatial abilities. They also found that the attention domain of Hispanic patients with AD was significantly less impaired than the language domain. These differences in the presentations of AD between our sample and the Hispanic participants of the study by Weissberger et al. (2019) may be attributable to several factors, such as lifestyle and geographical context, as they were living in the United States mainland while the participants in the study are currently living in Puerto Rico.

The results of our study also revealed correlations between demographic characteristics and the neuropsychological performance of the Puerto Rican participants with AD.

- ***Age***

The results of our study revealed a strong correlation between age and advanced cognitive impairment. Our subjects with advanced age performed worse on neuropsychological tests that assessed mild cognitive impairment (MMSE), sustained attention, visuomotor tracking, cognitive flexibility (Color Trails Test 1), and motor speed and dexterity (Grooved Pegboard), suggesting prefrontal, medial temporal, and occipital cortices involvement.

- *Education*

Results showed better neuropsychological performance in participants with higher education levels (more than 12 years) on tests of perceptual organization and discrimination of abstract patterns (i.e., Block Design of the EIWA-III), visual motor coordination, new visual learning, and speed of mental processing (i.e, Digit-Symbol Coding of the EIWA-III). This suggests the deterioration of new learning and memory, attentional skills, and general neurocognitive functioning in participants with lower educational levels, proposing that progression of advanced AD increases with low education. In other words, the Puerto Rican participants with AD that have higher levels of education performed better in tasks that are associated with the activation of frontal, temporal, and parietal cortices. This is consistent with the results of Roe et al. (2007), in which individuals with AD who have lower years of education show less flexibility, less tolerance to frustration, and progression of cognitive impairments in pre-clinical stages of AD. Their results support the idea that more years of education can facilitate the management of AD pathology. Several studies have suggested that individuals with higher levels of education have a greater quality of neural connections throughout the brain, increased flexibility and adaptability, and the ability to manage stressors and changes (Roe et al., 2007). This idea is commonly known as “cognitive reserve” (CR), which is a neuropsychological construct that represents dynamic cognitive and brain processes influenced by an individual’s life experiences that support adaptability upon neurological changes (Stern et al., 2018). According to Stern (2009), individuals who possess a greater neural network or cognitive reserve will show improved task performance, as they cope better with brain damage.

- ***Gender***

Results showed no significant relationship between gender and neuropsychological performance in participants with AD. Contrary to our findings, some studies have found gender differences in neurocognitive performance of individuals with AD and MCI (i.e., early stages of AD) (Beinhoff et al., 2008; Laws et al., 2016). Beinhoff and colleagues (2008) found that females with MCI performed better in verbal episodic memory tasks than males, but males with AD performed better in visuospatial episodic memory tasks. Moreover, Laws et al. (2016) found that males with AD performed better in neurocognitive domains that included language, semantic and visuospatial abilities, and episodic memory. Although in their study Henderson and Buckwalker (1994) found that females with AD performed better in the language domain, no significant differences by gender were observed in other neurocognitive tasks. Nevertheless, another study found no differences between males and females in language functioning (Bayles et al., 1999). The findings of our study do not support the impact of gender on

neuropsychological performance. It is possible that lack of differences may be due to having more females (72%) than males (28%) in the sample.

The results of this study suggest that Puerto Ricans with AD seem to manifest a temporo-frontal pattern of decline and presentation of AD. This pattern was characterized by severe deficits in verbal memory followed by attention, executive function, non-verbal memory, and motor deficits. Additionally, results suggest that advanced age and low educational achievement are significant risk factors for AD in Puerto Ricans living in the island. The described neuropsychological profile may facilitate a better understanding of AD pathology in Puerto Ricans and facilitate further neurocognitive rehabilitation and evidenced-based treatment and recommendations for this underrepresented population. Describing their neuropsychological profile may be a vital step in planning and enhancing the effectiveness of the neurocognitive rehabilitation.

Neuropsychological rehabilitation (NPR), which offers specialized individualized and group interventions are based on the neuropsychological profiles of a particular population with the aim of enhancing neurocognitive abilities to slow down the progression of AD (Abrisqueta-Gomez et al., 2004). NPR includes the practice of techniques and strategies to improve temporal orientation, attention, language, memory, and daily functioning and it has been shown to increase quality of life by reducing cognitive, emotional, psychological, and social burden associated with the disease (Abrisqueta-Gomez et al., 2004; Viola et al., 2011). NPR is most effective when AD is diagnosed at its early stages, thus our findings can be used to identify and predict a potential pattern of neurocognitive deficits that can be targeted before they worsen.

- ***Limitations***

This study had several limitations that must be considered. The first limitation was the degree of accuracy of the data collected from the clinical diagnoses, since AD diagnoses of participants were confirmed through interviews with caregivers and some caregivers reported that comprehensive evaluations (i.e., neuroimaging along with neuropsychological evaluations) were not performed by specialists. The lack of neuroimaging studies and neuropsychological evaluations to complement accurate diagnoses may have prevented a pure experimental sample with probable AD. The second limitation considered in the study was that most of the subjects were at a severe stage of AD, which may limit the generalizability of results. While this study did not represent all the Puerto Rican population, it may set the foundation for future studies to further investigate and describe the clinical manifestations and course of AD in Puerto Ricans.

- ***Future Research***

Taking into consideration the limitations of this study, future studies should place a greater emphasis on more inclusive diagnostic criteria when selecting subjects with AD. Neurological screenings, blood work, and brain imaging studies may aid in confirming true cases of AD and rule out other possible neurodegenerative disorders. Another subject to consider for future research is expanding the sample size. This can be achieved through an increase of the demographic areas of evaluation and distributing research subjects into initial and moderate stages, which would aid in results analysis and may allow for generalization of results.

Studies that evaluate specific characteristics of the population associated with risks and protective factors linked to AD are desperately needed. Recent literature suggests that factors such as occupation, cognitive, physical exercise, diet, and social environment can support the determination of the neuropsychological profile of AD (Alzheimer's Association, 2019). In early stages, symptoms are usually associated with the temporal lobe, which include brain areas linked to new learning and working memory (American Psychiatric Association, 2013). However, in our study, fatigue, slow processing speed, and very limited cognitive abilities were also found. When this also occurs, it has been speculated that neuropathology has spread to other cortical and subcortical areas (Reed et al., 2007). A better understanding of how AD progresses in the Puerto Rican population, which includes genetic make-up, risk factors, and lifestyle habits will direct and guide better treatments and management of the disease in the population.

V. CONCLUSION

The current study described AD's impact across neurocognitive domains in Puerto Ricans with the aim of providing detailed demographic and neuropsychological knowledge that can improve the treatment approach and management of the disease in the Puerto Rico health system. Our results showed advanced neurocognitive impairments in memory, language, visuospatial abilities, executive functions, and motor skills in a group of Puerto Ricans with AD. However, by revealing the pattern of neuropsychological deficits (i.e., temporo-frontal presentation of AD) and demographic characteristics of the sample, our findings may enable early identification of neurocognitive deficits and delay of symptom progression, which could be targeted by neurocognitive rehabilitation training. These results highlight the importance of assessing, identifying, monitoring, and treating AD in its early stages to encourage enhanced treatment of the disease and improve quality of life in the Puerto Rican population with AD.

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