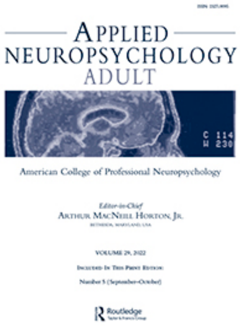

Routledge
Taylor & Francis Group

Applied Neuropsychology: Adult

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/hapn21

Normative data for Verbal Fluency and Object Naming Tests in a sample of European Portuguese adult population

Selene G. Vicente, Itziar Benito-Sánchez, Fernando Barbosa, Nuno Gaspar, Artemisa R. Dores, Diego Rivera & Juan Carlos Arango-Lasprilla

To cite this article: Selene G. Vicente, Itziar Benito-Sánchez, Fernando Barbosa, Nuno Gaspar, Artemisa R. Dores, Diego Rivera & Juan Carlos Arango-Lasprilla (2022) Normative data for Verbal Fluency and Object Naming Tests in a sample of European Portuguese adult population, Applied Neuropsychology: Adult, 29:5, 1268-1279, DOI: 10.1080/23279095.2020.1868472

To link to this article: https://doi.org/10.1080/23279095.2020.1868472

Published online: 13 Jan 2021.

APPLIED NEUROPSYCHOLOGY: ADULT
2022, VOL. 29, NO. 5, 1268–1279
https://doi.org/10.1080/23279095.2020.1868472

Normative data for Verbal Fluency and Object Naming Tests in a sample of European Portuguese adult population

Selene G. Vicente[a], Itziar Benito-Sánchez[b,c], Fernando Barbosa[d], Nuno Gaspar[a], Artemisa R. Dores[d,e], Diego Rivera[f], and Juan Carlos Arango-Lasprilla[b,g,h]

[a]Centre for Psychology, Faculty of Psychology and Education Sciences, University of Porto, Porto, Portugal; [b]Biocruces Bizkaia Health Research Institute, Barakaldo, Spain; [c]Biomedical Research Doctorate Program, University of the Basque Country (UPV/EHU), Leioa, Spain; [d]Faculty of Psychology and Education Sciences, Laboratory of Neuropsychophysiology, University of Porto, Porto, Portugal; [e]School of Health, Polytechnic of Porto, Porto, Portugal; [f]Departamento de Ciencias de la Salud, Universidad Pública de Navarra, Pamplona, Spain; [g]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain; [h]Department of Cell Biology and Histology, University of the Basque Country (UPV/EHU), Leioa, Spain

ABSTRACT

The purpose of the present study was to calculate the construct validity, internal consistency and normative data of the Phonological Verbal Fluency Test (letters F, A, S, and M), Semantic Verbal Fluency Test (Animals, Fruits and Professions categories), and Boston Naming Test (short and standard version), and to generate normative data for these tests after adjusting for age, education, and sex. A sample of 293 European Portuguese adults participated in the study. Results showed adequate construct validity and internal consistency for all of the tests and the final multiple regression models found that age and education were significantly associated with P-VFT (letters F, A, S, and M), S-VFT (Animals, Fruits and Professions categories), and BNT performance. Sex was only found to have an effect on the fruit category, with women scoring higher than men. The normative data provided in this study will contribute to improving the clinical practice of neuropsychology in Portugal.

KEYWORDS
European Portuguese; Naming; neuropsychological tests; standardization; Verbal Fluency

Introduction

Verbal fluency is a cognitive function that facilitates information retrieval from memory through executive functions such as selective attention, internal response generation, mental set-shifting, and self-monitoring (Patterson, 2011). The most used measures to assess this cognitive function are verbal fluency tests (VFT; semantic and phonemic) which allow understanding about the organization of language and provide information about attention, short-term memory, initiation, mental flexibility, response inhibition, processing speed, and semantic memory (Lezak et al., 2012; Ruff et al., 1997).

Verbal fluency tests are widely used for both research and neuropsychological examinations since they are easy to administer and sensitive to a wide variety of cognitive dysfunctions (Lezak et al., 2004) including brain injury (Henry & Crawford, 2004a; Kavé et al., 2011; Raskin & Rearick, 1996), stroke (Brady et al., 2001; Hochstenbach et al., 1998; Kim et al., 2011), neurodegenerative conditions such as Alzheimer's disease (Clark et al., 2009; McDowd et al., 2011), mild cognitive impairment (Gardini et al., 2013), Parkinson's disease (Henry & Crawford, 2004b; McDowd et al., 2011), epilepsy (Gleissner & Elger, 2001; Thompson & Duncan, 2005), and psychiatric disorders such as schizophrenia (Phillips et al., 2004).

Some sociodemographic variables have been associated with performance on both phonemic and semantic fluency tests (Boone et al., 2007; Labos et al., 2013). It has been reported that age influences phonemic fluency performance, increasing from childhood to adulthood, and beginning to decline in older ages (Auriacombe et al., 2001; Brickman et al., 2005; Kavé, 2005; Loonstra et al., 2001; Strauss et al., 2006; Tombaugh et al., 1999). Nevertheless, semantic fluency reached a peak between 10 and 12 years old (Sauzéon et al., 2004) and starts to decline around age 20 (Mitrushina et al., 2005). Education level is also related to verbal fluency, improving performance across childhood, with a dramatic increase during the first two years of formal education (Barry et al., 2008; Mitrushina et al., 2005; Strauss et al., 2006). Moreover, those with more years of education tend to achieve higher scores on both tests (Strauss et al., 2006). Some studies have shown that cultural differences, ethnicity, and geographic region are associated with the performance in phonemic and semantic fluency (Ardila & Moreno, 2001; Ostrosky-Solís et al., 2004). Specifically, Caucasians and non-Hispanics tend to produce more words on phonemic and semantic tasks than individuals from other ethnic groups (Strauss et al., 2006). Regarding sex, while some

CONTACT Juan Carlos Arango-Lasprilla jcalasprilla@gmail.com BioCruces Health Research Institute, Cruces University Hospital, IKERBASQUE, Basque Foundation for Science, Plaza de Cruces s/n., Bilbao 48013, Spain.

researchers have found that sex affects the performance on verbal fluency tests (Capitani et al., 1999; Rivera et al., 2019; Weiss et al., 2003, 2006), with women scoring higher than men, most studies report no sex differences (Benito-Cuadrado et al., 2002; Boone, 1999; Cavaco et al., 2013; Gladsjo et al., 1999; Olabarrieta-Landa, Rivera, Galarza-del-Angel, et al., 2015; Tombaugh et al., 1999).

Normative data is available for verbal fluency for several languages in many countries such as Spain (Alegret et al., 2012; Benito-Cuadrado et al., 2002; Peña-Casanova et al., 2009; Villodre et al., 2006), Italy (Zarino et al., 2014), Greece (Kosmidis et al., 2004), The Netherlands (Van Der Elst et al., 2006), Sweden (Tallberg et al., 2008), Norway (Egeland et al., 2006), South Africa (de Picciotto & Friedland, 2001), Saudi Arabia (Khalil, 2010), Israel (Kavé, 2005), India (Waldrop-Valverde et al., 2015), Korea (Kim et al., 2013; Ryu et al., 2012), Hong Kong (Lee et al., 2002), Australia (Elkadi et al., 2006), Canada (Tombaugh et al., 1999), Argentina (Butman et al., 2000; Olabarrieta-Landa, Rivera, Galarza-del-Angel, et al., 2015; Zanin et al., 2010), Mexico (Chávez-Oliveros et al., 2015; Olabarrieta-Landa, Rivera, Galarza-del-Angel, et al., 2015), Brazil (Machado et al., 2009; Zimmermann et al., 2014), Colombia (Olabarrieta-Landa, Rivera, Vergara Torress, et al., 2015), Bolivia, Chile, Cuba, El Salvador, Guatemala, Honduras, Paraguay, Peru, and Puerto Rico (Olabarrieta-Landa, Rivera, Galarza-del-Angel, et al., 2015).

Another important aspect of language is naming, which refers to several processes that are usually activated sequentially such as the perceptual recognition of the stimulus, the participation of the semantic system, and the phonological program containing the driving information to articulate the names that have been previously activated (Olabarrieta-Landa, Rivera, Morlett-Paredes, et al., 2015). The Boston Naming Test (BNT; Kaplan et al., 1983) is one of the neuropsychological assessment tools most widely used to measure language abilities, including confrontation naming or word retrieval (Rabin et al., 2005; Strauss et al., 2006).

Given its characteristics, the BNT is used to detect communication disorders and different types of aphasia in people with diverse clinical pathologies such as dementia (Balthazar et al., 2008; Chosak Reiter, 2000; Laine et al., 1997; Lukatela et al., 1998; Taler & Phillips, 2008; Tsolaki et al., 2003), stroke (Park et al., 2016; Wall et al., 2017), traumatic brain injury (Kerr, 1995; Whiteside et al., 2015), and epilepsy (Loring et al., 2008).

Studies have demonstrated that demographic characteristics such as age (Au et al., 1995; Fernández-Blázquez et al., 2012; Hall et al., 2012; Zec et al., 2007a) and education (Elkadi et al., 2006; Fernández-Blázquez et al., 2012; Neils et al., 1995; Olabarrieta-Landa, Rivera, Morlett-Paredes, et al., 2015) influence the performance on the BNT, demonstrating that the higher the educational level, the better the scores. However, age seems to influence the performance of elderly people. In fact, no decline appears to occur until individuals turn 70 (Quinones-Ubeda et al., 2004). Although the relationship between sex and BNT performance seems to be weak and not well-established, some studies have found that men outperform women in young adult samples, specifically in items that are more related to traditional male roles (Aranciva et al., 2012).

Normative data for the BNT has been collected in numerous countries for several languages and age ranges which confirms its popularity: Spain (Quinones-Ubeda et al., 2004; Rami et al., 2008), Sweden (Tallberg, 2005), Belgium (Mariën et al., 1998), The United States of America (USA; Lucas et al., 2005), Canada (Tombaugh & Hubley, 1997), Australia (Worrall et al., 1995), Korea (Kim & Na, 2004), New Zealand (Barker-Collo, 2001), Colombia (Quijano et al., 2015), Brazil (Miotto et al., 2010), Bolivia, Chile, Cuba, El Salvador, Guatemala, Mexico, Paraguay, Peru, Puerto Rico (Olabarrieta-Landa, Rivera, Morlett-Paredes, et al., 2015).

Although the VFT and the BNT have been translated into numerous languages, no normative data for Portugal has been systematically collected to date. Regarding semantic and phonemic fluency tests, Cavaco et al. (2013) conducted a normative study for the Portuguese population aged between 18 and 98 with educational backgrounds ranging from 0 to 20 years. However, they used the animal's category to assess semantic fluency, while the letters M, R, and P were used for phonemic fluency. Although the letters M, R, and P have also been used in studies for English and Brazilian-Portuguese languages, in the present study we will use the letters F, A, S, and M for phonemic fluency. As for semantic verbal fluency, we will use the animals, fruits and professions categories which are very commonly used by European Portuguese neuropsychologists in clinical practice.

Therefore, the purpose of the present study will be to calculate the construct validity and internal consistency of the Phonemic Verbal Fluency Test (P-VFT: letters F, A, S, and M), Semantic Verbal Fluency Test (S-VFT: Animals, Fruits and Professions categories), and BNT (short and standard version) and to generate normative data for these tests in a large sample of European Portuguese adults aged 18–91 years, adjusted by age, education, and sex.

Method

Participants

293 healthy individuals were recruited from Porto District, Portugal. The majority of the sample were women (62.8%), with a mean age of 49.7 (SD = 20.9; range = 18–91), and a mean number of years of education of 10.5 (SD = 5.1; range = 3–25). The maximum error of the sample size was ≈ 0.057 (accuracy level ≈ 94.3%). The maximum error was established using classical estimation assuming infinite (very large) population sizes, where the case of maximum uncertainty was assumed ($\pi = 1$ to $\pi = 0.5$) and a confidence interval of 95% (Guàrdia-Olmos et al., 2007). The sampling strategy was determined by taking into consideration factors such as literacy level; percentage of people with primary, secondary, and post-secondary education; and age distribution (Instituto Nacional de Estatística, 2012). See Table 1 for

Table 1. Demographic characteristics of the sample.

		Age		Education		Sex	
Age group	n_i	Mean	*SD*	Mean	*SD*	Woman n_i	Man n_i
20 ± 2 years	19	20.7	1.5	12.7	2.1	13	6
25 ± 2 years	56	24.5	1.3	15.3	2.1	37	19
30 ± 2 years	16	30.4	1.6	15.3	3.8	11	5
35 ± 2 years	11	34.8	1.7	13.6	4.7	4	7
40 ± 2 years	18	40.4	1.4	12.1	4.4	7	11
45 ± 2 years	13	44.7	1.5	11.4	5.5	6	7
50 ± 2 years	28	50.2	1.2	9.6	4.8	15	13
55 ± 2 years	11	54.9	1.8	11.2	4.8	9	2
60 ± 2 years	20	59.9	1.4	9.7	4.2	15	5
65 ± 2 years	27	65.3	1.3	7.3	4.1	20	7
70 ± 2 years	21	69.4	1.5	8.0	4.3	15	6
75 ± 2 years	25	74.9	1.6	5.8	3.7	13	12
80 ± 2 years	11	79.3	1.6	4.3	1.6	7	4
>82	17	86.4	2.6	4.7	2.3	12	5
Total	293	49.8	20.9	10.5	5.2	184	109

Note. SD = Standard Deviation.

more details regarding the demographic characteristics of the sample.

To be part of the study, participants had to meet the following requirements: (a) were between 18 and 95 years of age; (b) were born and currently live in the country where the protocol was conducted; (c) spoke European Portuguese as their primary language; (d) had completed at least one year of formal education; (e) were able to read and write at the time of the evaluation; (f) scored ≥24 on the Mini-Mental State Examination (MMSE; Folstein et al., 1975; Morgado et al., 2009); (g) scored ≥9 on the Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001); and (h) scored ≥90 on the Barthel Index (Mahoney & Barthel, 1965).

The participants also completed a self-report questionnaire about their medical history and health status. Subjects were determined to be ineligible if they reported or endorsed the following: (a) medical services received for diagnosed neurological or psychiatric conditions; (b) daily consumption and/or use of an illicit substance; (c) history of systemic disease (e.g., diabetes mellitus); (d) regular use of pain or other medications that may impact cognitive functioning; and/or (e) severe visual and/or hearing impairments. The Ethics Committee of the University of Porto (Oporto, Portugal) approved this study. All participants were volunteers who did not receive financial compensation for their participation.

Instruments and measures

Verbal Fluency Test (VFT; Benton & Hamsher, 1989**).** The two more commonly used modalities of the VFT are phonemic and semantic verbal fluency. Phonemic Verbal Fluency Test (P-VFT) consists of producing as many words as possible in 60 s, beginning with a certain letter (for this study, F, A, S, and M were used). Semantic Verbal Fluency Test (S-VFT), involves producing as many words as possible belonging to a given category in 60 s (in this study, animals, fruits, and professions). The total score consists of the total correct answers for each letter or each category. The test administration and the scoring procedures was done according to Strauss et al. (2006, p. 499).

The Boston Naming Test (BNT; Kaplan et al., 2005). In the BNT, examinees are shown target stimuli and asked to identify each target item within a 20-s interval per trial. If the participant does not give a correct answer spontaneously, a semantic cue is given (in case of a misrecognition error) or a phonological cue that is the initial sound of the target word (when the semantic cue is still not enough to generate a response, or if there has been an error that is not of misrecognition during the spontaneous response). The total score was considered as the sum of correct naming spontaneous answers plus correct naming answers followed by a semantic cue. The standard (60 pictures) and the short (15 pictures) versions were used in this study.

Since there is not a Portuguese version of the BNT, translation, and validation of the names for each picture as well as of the semantic and phonological cues was conducted by the researchers in advance. The words were translated from Spanish to Portuguese followed by back-translation from Portuguese to Spanish by a bilingual speaker. The pictures were presented to a group of university students ($n = 80$) in a pilot study. All pictures obtained a percentage of nomination agreement of over 80%.

Procedure

Two Portuguese psychologists were recruited and trained in the administration of a comprehensive neuropsychology battery that includes the VFT and the BNT tests. In order to attain a standard management and administration process of the tests, the following tools and visual aids were established: (a) a randomized list to determine the order of test administration for each participant in order to avoid order bias and cognitive conditioning; (b) a template in Microsoft Excel for entering information to limit bias input information; (c) illustrated examples were used to show the most frequent errors in the administration and scoring procedures; and (d) a virtual folder with a security key, administered by the study coordinator to track data entry. Data collection took place over a period of six months in the district of Porto, Portugal. The tests were administered in a single visit as part of a complete neuropsychological battery lasting about 70 minutes. Before testing administration, each participant completed and signed informed consent.

Statistical analyses

Validity and internal consistency

A confirmatory factor analysis (CFA) was conducted to evaluate the construct validity of the neuropsychology test assuming a priori model fit composes of three factors: (1) P-VFT (letters F, A, S, and M); (2) S-VFT (Animals, Fruits, and Professions categories); (3) BNT (short and standard BNT total scores). Several indices were used to test the goodness of fit: ratio X^2/df, the root mean square error of approximation (RMSEA), comparative fit index (CFI), and

Incremental fit index (IFI). The internal consistency of each factor was calculated through the Cronbach alpha method.

Effects of demographic variables

The effects of demographic variables on all scores (VFT: letters F, A, S, and M; Animals, Fruits, and Professions categories; and short and standard BNT total scores) were evaluated by means of multiple regression analyses. For each variable, separate regression models were fitted to establish variable-specific normative data. The full regression models included as predictors: age, age^2, education, education^2, sex, and all two-way interactions between these variables. Age and education were centered (age in years $- \overline{X}_{Age}$ in the sample; education in years $- \overline{X}_{Educ.}$ in the sample) before computing the quadratic age and education to avoid multicollinearity (Kutner et al., 2005). The quadratic function of age and years of education were added in the full model to allow for quadratic effects between these predictors and each test score. Sex was dummy coded as man = 1 and woman = 0. The full regression model can be formally described as:

$$\hat{Y}_i = B_0 + B_1 \cdot (\text{Age} - 49.7)_i + B_2 \cdot (\text{Age} - 49.7)_i^2 + B_3 \cdot (\text{Education} - 10.5)_i + B_4 \cdot (\text{Education} - 10.5)_i^2 + B_5 \cdot \text{Sex}_i + B_k \cdot \text{Interactions}_i + \varepsilon_i$$

with the term Interactions$_i$ referring to all two-way interactions between the fixed effects. In the regression model, the predictors that were not statistically significant were removed, and the model was fitted again. In the construction of the step model, no predictor was removed as long as it was also included in a higher order term in the model (Aiken et al., 1991). The following assumptions were evaluated for all regression models: multicollinearity (Variance Inflation Factor [VIF] $\leq$10), homoscedasticity (participants were grouped into quartiles of the predicted scores and the Levene's test was applied on the residuals), normality of the standardized residuals (Kolmogorov–Smirnov test and histogram plots), and the existence of influential values assess (calculation of the maximum Cook's distance [D_i]). The Cook's distance was measured using D_i to the $F(p, n-p)$ distribution, where p is the number of regression parameters (including the intercept) and n is the sample size. Influential values are considered when the obtained percentile value is equal to or higher than 50 (Kutner et al., 2005). An alpha level of 0.01 was used in all analyses (Van Breukelen & Vlaeyen, 2005; Van der Elst et al., 2012).

Procedure to generate normative data

Using the final regression model that was obtained at the end of the stepwise procedure, normative data adjusted for demographic variables were established by means of a four-step procedure (Rivera et al., 2019, 2020): (1) The expected test score ($\hat{Y}_i$) is computed based on the fixed effect parameter estimates of the established final regression model: $\hat{Y}_i = B_0 + B_1X_{1i} + B_2X_{2i} + \ldots + B_KX_{Ki}$. (2) To obtain the residual value: $e_i = Y_i - \hat{Y}_i$. (3) Using the residual standard deviation (SD_e), the value provided by the regression model (see Table 2), residuals were standardized: $z_i = e_i/SD_e$. (4) Finally, using the standard normal cumulative distribution function, the exact percentile corresponding to the z_i, if the model assumption of normality of the residuals was met in the normative sample, or via the empirical cumulative distribution function of the standardized residuals, if the standardized residuals were not normally distributed in the normative sample. This four-step process was applied for each test score (letters F, A, S, and M; animals, fruits, and professions' categories; and short and standard BNT total scores). All analyses were performed using SPSS version 25 (IBM Corp., 2017) and R program 3.6.3 for Linux–Ubuntu (R Development Core Team, 2020). The *Rcmdr* library (Fox, 2005) was used to conduct the CFA analyses.

Table 2. Standard Deviation (residual) for final multiple linear regression models.

Score	Predicted value ($\hat{Y}_i$)	SD_e (residual)
Letter F	All values	3.853
Letter A	$\leq$6.747	2.404
	6.748–10.480	4.171
	10.481–12.478	4.170
	$\geq$12.479	4.113
Letter S	$\leq$7.743	2.665
	7.744–10.744	3.895
	10.745–12.559	4.420
	$\geq$12.560	3.798
Letter M	All values	3.515
Animals	$\leq$12.660	3.004
	12.661–17.882	3.941
	17.883–20.264	4.293
	$\geq$20.265	4.795
Fruits	All values	2.898
Professions	All values	3.017
BNT Short	All values	1.837
BNT Standard	All values	5.298

Note. BNT: Boston Naming Test.

Normative data calculator

The four-step normative procedures explained above offer the clinicians the ability to determine an exact percentile for a participant who has a specific score on the letter, semantic verbal fluency test, short BNT, and standard BNT. This method may be prone to human error, due to the number of calculations required. To facilitate its use, the authors created a calculator in Microsoft Excel where clinicians should include patient information (gross score for the specific test score, age, education, and sex) to calculate the z-score (z_i) and the percentile. This tool is freely available for all users and may be downloaded at https://neuropsychologylearning.com/datos-normativos-archivos-descargables/.

Results

A CFA was run using data from the nine language raw scores and the three-factor structure. Maximum likelihood estimation was used, and indicators were modeled as continuous variables. The goodness-of-fit tests provided initial evidence that overall, the three-factor solution was an

Table 3. Final multiple linear regression models for Phonemic Verbal Fluency.

Score	Variable	B	Std. Error	t	Std. B	p	Adjusted R^2
Letter F	(Intercept)	11.976	0.498	24.057		<0.001	0.378
	Age	−0.014	0.016	−0.880	−0.058	0.380	
	Age^2	−0.002	0.001	−2.816	−0.133	0.005	
	Education	0.493	0.063	7.824	0.515	<0.001	
	Education^2	0.005	0.010	0.521	0.028	0.603	
	Sex	1.259	0.702	1.794	0.123	0.074	
	Edu^2 × Sex	−0.064	0.023	−2.847	−0.198	0.005	
Letter A	(Intercept)	10.486	0.348	30.092		<0.001	0.409
	Age	−0.026	0.015	−1.785	−0.110	0.075	
	Age^2	−0.002	0.001	−2.605	−0.118	0.010	
	Education	0.516	0.059	8.724	0.537	<0.001	
Letter S	(Intercept)	11.128	0.344	32.316		<0.001	0.371
	Age	−0.022	0.014	−1.549	−0.098	0.122	
	Age^2	−0.002	0.001	−3.436	−0.161	0.001	
	Education	0.460	0.059	7.869	0.500	<0.001	
Letter M	(Intercept)	10.413	0.206	50.611		<0.001	0.380
	Education	0.535	0.040	13.415	0.618	<0.001	

adequate fit with the scores, because the ratio of the X^2/degrees of freedom was 2.14 (critical ratio cutoff of 2.0) RMSEA of 0.06 [90% CI: 0.03 − 0.08] (an RMSEA of 0.08 or lower indicates an adequate fit). The CFI, and IFI were 0.989, where 0.90 and above is considered as good fit (Bentler, 1990). Overall, these goodness-of-fit indices suggest that the three-factor solution fit showed an adequate construct validity to P-PVF, S-SVF and BNT. Internal consistency was adequate for the three neuropsychological tests (P-VFT = 0.93 [CI = 0.91 − 0.93]; S-VFT= 0.86 [CI = 0.84 − 0.89]; BNT = 0.73 [CI = 0.71 − 0.75]).

The assumptions of multiples regression analysis were met for all final models. There was no multicollinearity (all VIF values < 5.153; all tolerance values < (1) or influential cases (all Cook's D < 0.259; relating this value to an F(6, 287) distribution yields a percentile value of 5). Levene's test suggested that there was homoscedasticity in all the models except for the letter A, S, and animals' categories. The lack of homoscedasticity was corrected by estimating residual standard deviation (SD_e) value by quartiles of the predicted scores $(\hat{Y}_i)$ to each regression model (see Table 2). Standardized residuals of the models were normally distributed (all $p > 0.01$, as evaluated with the Kolmogorov–Smirnov test) so standard normal cumulative distribution were used to convert z scores (z_i) to percentiles.

Phonemic Verbal Fluency

All final multiple regression models for letters F, A, S, and M scores were significant (Table 3). The amount of variance explained after adjusting for the number of predictors in letter F final model was 37.8%, for letter A model 40.9%, for letter S model 37.1%, and for letter M model 38%. The scores for letters F, A, and S were affected by a quadratic age effect, showing a curvilinear pattern of the scores according to age. All scores were affected by education so that those with higher education generated more words in each letter. For Letter F, an interaction between education^2 and sex was found, so that women outperformed men when they both have between 1–6 and 15 or more years of education. Instead, men outperformed women when they both have between 7–14 years of education (see Figure 1).

Semantic Verbal Fluency

All final multiple regression models for animals, fruits, and professions categories were significant (Table 4). The amount of variance explained after adjusting for the number of predictors in animals' final model was 49.5%, for fruits model 42.5%, and for professions model 46.4%. All categories were affected by a quadratic age effect, showing a curvilinear pattern of the scores according to age. Fruits and professions' categories scores were affected by education so that those with higher education generated more words in each category. For the animals' category, an interaction between education^2 and age was found. Thus, young people with more years of education had better performance compared to those with fewer years of education. However, after 70 years of age, those with 10 years of education had similar performance compared to those with 1 or 5 years of education, but people with more than 15 years of education continued to outperform people with fewer years of education (see Figure 2). Finally, the participants' sex affected fruits' category scores, such that women scored higher than men.

Naming

All final multiple regression models for short and standard BNT were significant (Table 5). The amount of variance explained after adjusting for the number of predictors in the short BNT final model was 58.7%, and for the standard BNT final model was 58.7%. Short and standard BNT total scores were affected by a quadratic age and education effect, showing a curvilinear pattern of the scores.

Discussion

The purpose of the present study was to calculate the construct validity and internal consistency of the on P-VFT (letters F, A, S, and M), S-VFT (animals, fruits and professions categories), and BNT (short and standard version) and to generate normative data for these tests in a large sample of European Portuguese adults aged 18–91 years, adjusted by age, education, and sex. Results showed adequate construct validity and internal consistency for all of these tests, and

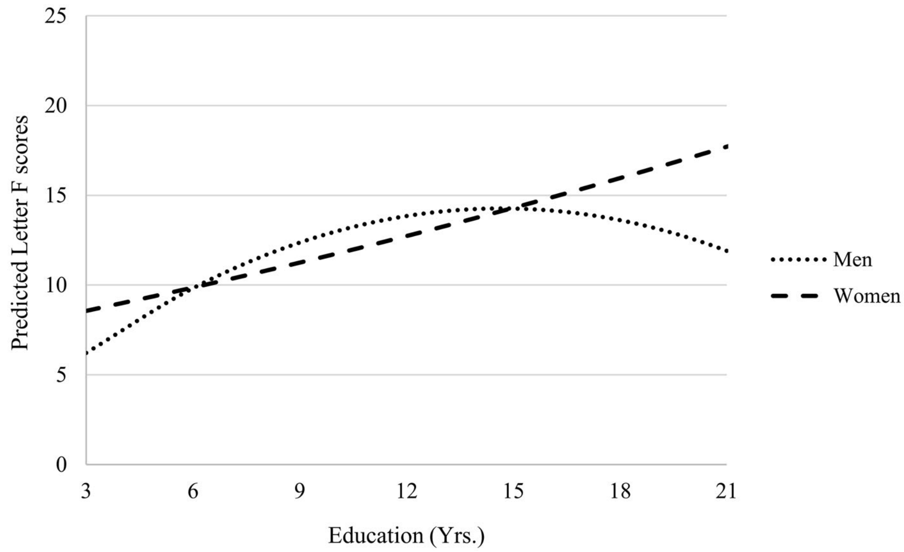

Figure 1. Predicted mean letter F scores as a function of education and sex. Predicted expected test scores were presented to show the fitted regression model $\hat{Y}_i = 11.976 + [-0.014 \cdot (\text{Age} - 49.7)] + [-0.002 \cdot (\text{Age} - 49.7)^2] + [0.493 \cdot (\text{Education}_i - 10.5)] + [0.005 \cdot (\text{Education}_i - 10.5)^2] + (1.259 \cdot \text{Sex}_i) + [-0.064 \cdot (\text{Education}_i - 10.5)^2 \cdot \text{Sex}_i]$.

Table 4. Final multiple linear regression models for Semantic Verbal Fluency.

Score	Variable	B	Std. Error	*t*	Std. B	*p*	Adjusted R^2
Animals	(Intercept)	17.817	0.435	40.928		<0.001	0.495
	Age	−0.140	0.021	−6.676	−0.509	<0.001	
	Age^2	−0.003	0.001	−3.837	−0.175	<0.001	
	Education	0.502	0.079	6.366	0.451	<0.001	
	Education^2	−0.010	0.010	−0.9.9	−0.043	0.348	
	AgeXEdu^2	0.002	0.001	2.706	0.255	0.007	
Fruits	(Intercept)	15.252	0.307	49.746		<0.001	0.425
	Age	−0.066	0.011	−5.853	−0.358	<0.001	
	Age^2	−0.002	<0.001	−4.071	−0.183	<0.001	
	Education	0.204	0.046	4.451	0.274	<0.001	
	Sex	−1.448	0.359	−4.038	−0.182	<0.001	
Professions	(Intercept)	13.993	0.277	50.517		<0.001	0.464
	Age	−0.062	0.012	−5.337	−0.313	<0.001	
	Age^2	−0.002	<0.001	−4.977	−0.172	<0.001	
	Education	0.308	0.047	6.537	0.384	<0.001	

Table 5. Final multiple linear regression models for BNT short and standard total scores.

Score	Variable	B	Std. Error	*t*	Std. B	*p*	Adjusted R^2
BNT short	(Intercept)	12.585	0.197	63.890		<0.001	0.587
	Age	−0.024	0.007	−3.323	−0.177	0.001	
	Age^2	−0.002	<0.001	−5.721	−0.219	<0.001	
	Education	0.304	0.030	10.256	0.546	<0.001	
	Education^2	−0.023	0.004	−5.243	−0.207	<0.001	
BNT standard	(Intercept)	51.247	0.568	90.240		<0.001	0.587
	Age	−0.074	0.021	−3.480	−0.185	0.001	
	Age^2	−0.007	0.001	−7.620	−0.291	<0.001	
	Education	0.813	0.086	9.503	0.506	<0.001	
	Education^2	−0.059	0.013	−4.664	−0.184	<0.001	

Note. BNT: Boston Naming Test.

the final multiple regression models found that age and education were significantly associated with P-VFT (letters F, A, S, and M), S-VFT (Animals, Fruits and Professions categories), and BNT performance. These demographic variables accounted for 37.1–40.9% of the variance in P-VFT, 42.5–49.3% in S-VFT, and 58.7% in BNT.

The influence of demographic variables on test performance was evaluated, showing that test scores increased linearly as a function of education on P-VFT, S-VFT, and BNT (see Tables 3–5). This means that higher educated individuals generated more words in phonemic and semantic verbal fluency measures and produced more corrected naming responses in BNT than less educated ones. Age was found to have a curvilinear effect in all measures (except for letter M in P-VFT), suggesting that performance on these tasks declined with age. Effects of sex were inconsistent and were only found for the fruits category (S-VFT), where women scored higher than men.

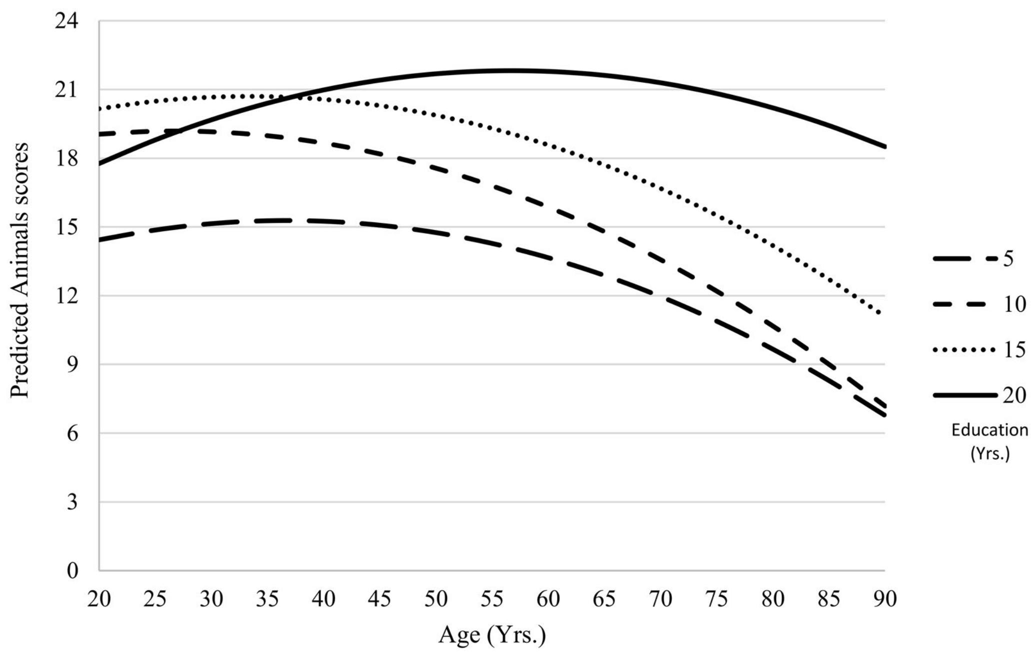

Figure 2. Predicted mean animals scores as a function of age and education.

The results of this study are consistent with previous normative studies where the performance on phonological and semantic verbal fluency tests improved with education (Acevedo et al., 2000; Brickman et al., 2005; Casals-Coll et al., 2013; Kavé, 2005; Kosmidis et al., 2004; Loonstra et al., 2001; Machado et al., 2009; Mack et al., 2005; Mathuranath et al., 2003; Mitrushina et al., 2005; Olabarrieta-Landa, Rivera, Galarza-del-Angel, et al., 2015; Steinberg et al., 2005; Tallberg et al., 2008; Zimmermann et al., 2014). Moreover, as in this study, Cavaco et al. (2013) and Rivera et al. (2019) reported a curvilinear effect of education in these tests. Also, verbal fluency test performance declined with age (Acevedo et al., 2000; Cavaco et al., 2013; Kavé, 2005; Loonstra et al., 2001; Lucas et al., 2005; Olabarrieta-Landa, Rivera, Galarza-del-Angel, et al., 2015; Zarino et al., 2014; Zimmermann et al., 2014). In contrast, in a study conducted by Olabarrieta-Landa, Rivera, Galarza-del-Angel, et al. (2015) with a total of 3977 healthy adults from 10 Latin American countries, they found that P-VFT scores (Letters F, A, and S) worsened with increasing age only in in Argentina, Honduras, Guatemala, and Paraguay.

Other studies have found no relationship between age and verbal fluency (Buriel et al., 2004; Casals-Coll et al., 2013; Hughes & Bryan, 2002; Machado et al., 2009; Steiner et al., 2008; Tallberg et al., 2008; Villodre et al., 2006). For example, in the study carried out by Casals-Coll et al. (2013) in Spain, which evaluated 179 healthy adults, the age effect was only observed for the category of fruits (S-VFT) and the letter R (P-VFT). However, this might have occurred because the sample only included individuals between 18 and 49 years of age; whereas other studies included a wider age range (18–92 years). Moreover, it seems that the age effect is particularly visible for persons over 70 years without neurological or psychiatric disease (Lezak et al., 2012).

Regarding the BNT, the results of this study are in agreement with previous normative studies that found better performance with a higher number of years of education (Elkadi et al., 2006; Fernández-Blázquez et al., 2012; Neils et al., 1995; Olabarrieta-Landa, Rivera, Morlett-Paredes, et al., 2015) and declined with age (Au et al., 1995; Fernández-Blázquez et al., 2012; Hall et al., 2012; Olabarrieta-Landa, Rivera, Morlett-Paredes, et al., 2015; Quinones-Ubeda et al., 2004; Zec et al., 2007a, 2007b). In a study conducted by Zec et al. (2007a) conducted with 1172 participants aged 20 to 101 years, BNT scores were generally found to decrease when participants were between 50 and 99 years old. Similarly, Aranciva et al. (2012) carried out a study with 179 Spanish healthy subjects aged 18–49 years and found no age effect; suggesting that performance on the BNT remains relatively stable until around age 50.

In the literature, the majority of studies have reported no associations between sex, and VFT and BNT performance (Aranciva et al., 2012; Benito-Cuadrado et al., 2002; Boone, 1999; Cavaco et al., 2013; Gladsjo et al., 1999; Harrison et al., 2000; Lucas et al., 1998; Olabarrieta-Landa, Rivera, Galarza-del-Angel, et al., 2015; Tombaugh et al., 1999). However, some studies have found significant sex effects on S-VFT when semantic categories such as fruits and professions are used (Kosmidis et al., 2004; Van Der Elst et al., 2006). The results of this study are consistent with results from previous studies that have shown no effect of sex on VFT and BTN performance. However, sex effects were found only for the fruits category, with women scoring higher than men.

The results of this study have some important implications. For instance, the P-VFT, S-VFT, and BNT are useful in neuropsychological evaluations to help confirm that the patient meets standardized criteria for some neurological disorders, to describe the patient's cognitive profile, including the severity and extent of impairments, and to measure the rate of decline and response to treatment (Zec et al., 2007b). The use of these tests (P-VFT, S-VFT, and BNT) in conjunction with other cognitive tests will be useful for neuropsychologists in Portugal in the differential diagnosis of aphasia or neurodegenerative disorders including early frontotemporal dementia, semantic dementia, and Alzeimer's Disease (AD), and early AD versus early vascular dementia (Zec et al., 2007b).

The current study has some limitations that should be taken into account when interpreting the results. First, participants are from the north region of Portugal (Oporto district) and regional and cultural variances within the country are possible but have not been taken into account. Similarly, the majority of participants came from urban areas and future studies should also include participants from rural areas. Second, although participants were speakers of European Portuguese, the proficiency level in other languages or dialects has not been measured and this variable might affect aspects of language including verbal fluency, confrontation naming, and word retrieval. The normative data obtained in this study should not be used or generalized to people from other Portuguese speaking countries (i.e., Brazil or the ex-colonies). Third, even though the wide range of educational backgrounds in the Portuguese population, participants with no formal education were not included in the sample and the norms should be interpreted with caution when used with such a population. It should be noted, however, that in a normative study for the Portuguese language conducted by Cavaco et al. (2013) in which illiterate people were included, they found that effects of education on semantic fluency (animals category) were only significant from 3 years of formal education. Additionally, subjects with a neurological and/or psychiatric condition were excluded from the study, but the inclusion and exclusion criteria were based on participants' self-report. Future normative research should include data for populations with neurological and/or psychiatric disorders as well as for children.

Despite the limitations, it is important to mention that compared to previous research that has developed normative data for these three neuropsychological tests, this study has a number of advantages. For instance, this study is one of the few studies that include interactions between sociodemographic variables in the final regression models. These interactions may improve results of the regression models with better R^2 values and lower Mean Square Errors than in previous research (e.g., Benito-Cuadrado et al., 2002, Casals-Coll et al., 2013; Cavaco et al., 2013; Machado et al., 2009; Olabarrieta-Landa, Rivera, Galarza-del-Angel, et al. 2015; Zarino et al., 2014).

Finally, the current study evaluates multicollinearity and influencing values, assumptions which were not addressed in some previous studies (e.g., Benito-Cuadrado et al., 2002, Casals-Coll et al., 2013; Cavaco et al., 2013; Machado et al., 2009; Olabarrieta-Landa, Rivera, Vergara Torres, et al., 2015; Zarino et al., 2014). In this study, multicollinearity is evaluated using VIF and controlled by centralizing the variables and influential values were evaluated using Cook distance. Assessing these assumptions is valuable because outliers have been found to strongly influence regression results (Williams et al., 2013).

In conclusion, the purpose of this study was to calculate the construct validity and internal consistency of the Phonological Verbal Fluency Test (letters F, A, S, and M), Semantic Verbal Fluency Test (Animals, Fruits and Professions categories), and Boston Naming Test (short and standard version), and to generate normative data for these tests after adjusting for age, education, and sex. Results showed adequate construct validity and internal consistency for all of the tests and the final multiple regression models found that age and education were significantly associated with P-VFT (letters F, A, S, and M), S-VFT (Animals, Fruits and Professions categories), and BNT performance). Sex was only found to have an effect on the fruit category, with women scoring higher than men. The normative data provided in this study will contribute to improving the clinical practice of neuropsychology in Portugal. Future studies in Portugal should continue this process of creating norms for those neuropsychological tests that do not have yet.

Disclosure statement

The authors declare that there is no conflict of interest.

ORCID

Itziar Benito-Sánchez http://orcid.org/0000-0003-1392-7449
Diego Rivera http://orcid.org/0000-0001-7477-1893
Juan Carlos Arango-Lasprilla http://orcid.org/0000-0002-7184-8311

References

Acevedo, A., Loewenstein, D. A., Barker, W. W., Harwood, D. G., Luis, C., Bravo, M., Hurwitz, D. A., Aguero, H., Greenfield, L., & Duara, R. (2000). Category fluency test: Normative data for English- and Spanish-speaking elderly. *Journal of the International Neuropsychological Society*, *6*(7), 760–769. https://doi.org/10.1017/s1355617700677032

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. Sage Publications.

Alegret, M., Espinosa, A., Vinyes-Junque, G., Valero, S., Hernandez, I., Tarraga, L., Becker, J. T., & Boada, M. (2012). Normative data of a brief neuropsychological battery for Spanish individuals older than 49. *Journal of Clinical and Experimental Neuropsychology*, *34*(2), 209–219. https://doi.org/10.1080/13803395.2011.630652

Aranciva, F., Casals-Coll, M., Sánchez-Benavides, G., Quintana, M., Manero, R. M., Rognoni, T., Calvo, L., Palomo, R., Tamayo, F., & Peña-Casanova, J. (2012). Spanish normative studies in a young adult population (NEURONORMA young adults project): Norms for the Boston Naming Test and the Token Test. *Neurología*, *27*(7), 394–399. https://doi.org/10.1016/j.nrleng.2011.12.010

Ardila, A., & Moreno, S. (2001). Neuropsychological test performance in Aruaco Indians: An exploratory study. *Journal of the International Neuropsychological Society*, *7*(4), 510–515. https://doi.org/10.1017/s1355617701004076

Au, R., Joung, P., Nicholas, M., Obler, L. K., Kass, R., & Albert, M. L. (1995). Naming ability across the adult life span. *Aging, Neuropsychology, and Cognition*, *2*(4), 300–311. https://doi.org/10.1080/13825589508256605

Auriacombe, S., Fabrigoule, C., Lafont, S., Amieva, H., Jacqmin Gadda, H., & Dartigues, J. F. (2001). Letter and category fluency in normal elderly participants: A population-based study. *Aging,* *Neuropsychology and Cognition*, *8*(2), 98–108. https://doi.org/10.1076/anec.8.2.98.841

Balthazar, M. L. F., Cendes, F., & Damasceno, B. P. (2008). Semantic error patterns on the Boston Naming Test in normal aging, amnestic mild cognitive impairment, and mild Alzheimer's disease: Is there semantic disruption? *Neuropsychology*, *22*(6), 703–709. https://doi.org/10.1037/a0012919

Barker-Collo, S. L. (2001). The 60-item Boston Naming Test: Cultural bias and possible adaptations for New Zealand. *Aphasiology*, *15*(1), 85–92. https://doi.org/10.1080/02687040042000124

Barry, D., Bates, M. E., & Labouvie, E. (2008). FAS and CFL forms of verbal fluency differ in difficulty: A meta-analytic study. *Applied Neuropsychology*, *15*(2), 97–106. https://doi.org/10.1080/09084280802083863

Benito-Cuadrado, M. M., Esteba-Castillo, S., Bohm, P., Cejudo-Bolivar, J., & Peña-Casanova, J. (2002). Semantic verbal fluency of animals: A normative and predictive study in a Spanish population. *Journal of Clinical and Experimental Neuropsychology*, *24*(8), 1117–1122. https://doi.org/10.1076/jcen.24.8.1117.8376

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, *107*(2), 238–246. https://doi.org/10.1037/0033-2909.107.2.238

Benton, A. L. & Hamsher, (1989). *Multilingual aphasia examination*. AJA Associates.

Boone, K. B. (1999). Neuropsychological assessment of executive functions: Impact of age, education, gender, intellectual level, and vascular status on executive test scores. In B. L. Miller & J. L. Cummings (Eds.), *The human frontal lobes: Functions and disorders*. (pp. 247–260). Guilford.

Boone, K. B., Victor, T. L., Wen, J., Razani, J., & Pontón, M. (2007). The association between neuropsychological scores and ethnicity, language, and acculturation variables in a large patient population. *Archives of Clinical Neuropsychology*, *22*(3), 355–365. https://doi.org/10.1016/j.acn.2007.01.010

Brady, C. B., Spiro, A., III, McGlinchey-Berroth, R., Milberg, W., & Gaziano, J. M. (2001). Stroke risk predicts verbal fluency decline in healthy older men: Evidence from the normative aging study. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *56*(6), P340–P346. https://doi.org/10.1093/geronb/56.6.p340

Brickman, A. M., Paul, R. H., Cohen, R. A., Williams, L. M., MacGregor, K. L., Jefferson, A. L., Tate, D. F., Gunstad, J., & Gordon, E. (2005). Category and letter verbal fluency across the adult lifespan: Relationship to EEG theta power. *Archives of Clinical Neuropsychology: The Official Journal of the National Academy of Neuropsychologists*, *20*(5), 561–573. https://doi.org/10.1016/j.acn.2004.12.006

Buriel, Y., Gramunt Fombuena, N., Böhm, P., Rodés, E., & Peña-Casanova, J. (2004). Fluencia verbal. Estudio normative piloto en una muestra española de adultos jóvenes (20 a 49 años). *Neurología*, *19*(4), 153–159.

Butman, J., Allegri, R. F., Harris, P., & Drake, M. (2000). Spanish verbal fluency test. Normative data in Argentina. *Medicina*, *60*(5), 561–564.

Capitani, E., Laiacona, M., & Barbarotto, R. (1999). Gender affects word retrieval of certain categories in semantic fluency tasks. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *35*(2), 273–278. https://doi.org/10.1016/s0010-9452(08)70800-1

Casals-Coll, M., Sánchez-Benavides, G., Quintana, M., Manero, R. M., Rognoni, T., Calvo, L., Palomo, R., Aranciva, F., Tamayo, F., & Pena-Casanova, J. (2013). Spanish normative studies in young adults (NEURONORMA young adults project): Norms for verbal fluency tests. *Neurología*, *28*(1), 33–40. https://doi.org/10.1016/j.nrleng.2012.02.003

Cavaco, S., Gonçalves, A., Pinto, C., Almeida, E., Gomes, F., Moreira, I., Fernandes, J., & Teixeira-Pinto, A. (2013). Semantic fluency and phonemic fluency: Regression-based norms for the Portuguese population. *Archives of Clinical Neuropsychology*, *28*(3), 262–271. https://doi.org/10.1093/arclin/act001

Chávez-Oliveros, M., Rodríguez-Agudelo, Y., Acosta-Castillo, I., García-Ramírez, N., de la Torre, G. R., & Sosa-Ortiz, A. L. (2015). Semantic verbal fluency in elderly Mexican adults: Reference values. *Neurología*, *30*(4), 189–194. https://doi.org/10.1016/j.nrl.2013.12.013

Chosak Reiter, J. (2000). Measuring cognitive processes underlying picture naming in Alzheimer's and cerebrovascular dementia: A general processing tree approach. *Journal of Clinical and Experimental Neuropsychology*, *22*(3), 351–369. https://doi.org/10.1076/1380-3395(200006)22:3;1-V;FT351

Clark, L. J., Gatz, M., Zheng, L., Chen, Y. L., McCleary, C., & Mack, W. J. (2009). Longitudinal verbal fluency in normal aging, preclinical, and prevalent Alzheimer's disease. *American Journal of Alzheimer's Disease & Other Dementiasr*, *24*(6), 461–468. https://doi.org/10.1177/1533317509345154

de Picciotto, J., & Friedland, D. (2001). Verbal fluency in elderly bilingual speakers: Normative data and preliminary application to Alzheimer's disease. *Folia Phoniatrica et Logopaedica*, *53*(3), 145–152. https://doi.org/10.1159/000052669

Egeland, J., Landrø, N. I., Tjemsland, E., & Walbaekken, K. (2006). Norwegian norms and factor-structure of phonemic and semantic word list generation. *The Clinical Neuropsychologist*, *20*(4), 716–728. https://doi.org/10.1080/13854040500351008

Elkadi, S., Clark, M. S., Dennerstein, L., Guthrie, J. R., Bowden, S. C., & Henderson, V. W. (2006). Normative data for Australian midlife women on category fluency and a short form of the Boston Naming Test. *Australian Psychologist*, *41*(1), 43–47. https://doi.org/10.1080/00050060500421642

Fernández-Blázquez, M. A., Ruiz-Sánchez de León, J. M., López- Pina, J. A., Llanero-Luque, M., Montenegro-Peña, M., & Montejo-Carrasco, P. (2012). *Nueva versión reducida del test de denominación de Boston para mayores de 65 años: Aproximación desde la teoría de respuesta al ítem* [A new shortened version of the Boston Naming Test for those aged over 65: An approach from item response theory]. *Revista de Neurologia*, *55*(7), 399–407. https://doi.org/10.33588/rn.5507.2012075

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state": A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*(3), 189–198. https://doi.org/10.1016/0022-3956(75)90026-6

Fox, J. (2005). Getting started with the R commander: A basic-statistics graphical user interface to R. *Journal of Statistical Software*, *14*(9), 1–42. https://doi.org/10.18637/jss.v014.i09

Gardini, S., Cuetos, F., Fasano, F., Pellegrini, F. F., Marchi, M., Venneri, A., & Caffarra, P. (2013). Brain structural substrates of semantic memory decline in mild cognitive impairment. *Current Alzheimer Research*, *10*(4), 373–389. https:// https://doi.org/10.2174/1567205011310040004.

Gladsjo, J. A., Schuman, C. C., Evans, J. D., Peavy, G. M., Miller, S. W., & Heaton, R. K. (1999). Norms for letter and category fluency: Demographic corrections for age, education, and ethnicity. *Assessment*, *6*(2), 147–178. https://doi.org/10.1177/107319119900600204

Gleissner, U., & Elger, C. E. (2001). The hippocampal contribution to verbal fluency in patients with temporal lobe epilepsy. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *37*(1), 55–63. https://doi.org/10.1016/S0010-9452(08)70557-4

Guàrdia-Olmos, J., Blanxart, M. F., Peró-Cebollero, M., & Turbany-Oset, J. (2007). *Análisis de datos en psicología* (1a ed.). Delta publicaciones.

Hall, J. R., Vo, H. T., Johnson, L. A., Wiechmann, A., & O'Bryant, S. E. (2012). Boston Naming Test: Gender differences in older adults with and without Alzheimer's dementia. *Psychology*, *03*(06), 485–488. https://doi.org/10.4236/psych.2012.36068

Harrison, J. E., Buxton, P., Husain, M., & Wise, R. (2000). Short test of semantic and phonological fluency: Normal performance, validity and test-retest reliability. *The British Journal of Clinical Psychology*, *39*(2), 181–191. https://doi.org/10.1348/014466500163202

Henry, J. D., & Crawford, J. R. (2004a). A meta-analytic review of verbal fluency performance following focal cortical lesions. *Neuropsychology*, *18*(2), 284–295. https://doi.org/10.1037/0894-4105.18.2.284

Henry, J. D., & Crawford, J. R. (2004b). Verbal fluency deficits in Parkinson's disease: A meta-analysis. *Journal of the International Neuropsychological Society*, *10*(4), 608–622. https://doi.org/10.1017/S1355617704104141

Hochstenbach, J., Mulder, T., van Limbeek, J., Donders, R., & Schoonderwaldt, H. (1998). Cognitive decline following stroke: A comprehensive study of cognitive decline following stroke. *Journal of Clinical and Experimental Neuropsychology*, *20*(4), 503–517. https://doi.org/10.1076/jcen.20.4.503.1471

Hughes, D., & Bryan, J. (2002). Adult age differences in strategy use during verbal fluency performance. *Journal of Clinical and Experimental Neuropsychology*, *24*(5), 642–654. https://doi.org/10.1076/jcen.24.5.642.1002

IBM Corp. (2017). *IBM SPSS statistics for Windows* (Version 25). IBM Corp.

Instituto Nacional de Estatística. (2012). *Censos - Resultados definitivos. Portugal – 2011.* https://bit.ly/2KQc5Wx

Kaplan, E. F., Goodglass, H., & Weintraub, S. (1983). *The Boston naming test (*2nd ed.*)*. Lea & Febiger.

Kaplan, E., Goodglass, H., & Weintraub, S. (2005). *Test de Vocabulario de Boston* (2° Edición). Editorial Médica Paramericana.

Kavé, G. (2005). Phonemic fluency, semantic fluency, and difference scores: Normative data for adult Hebrew speakers. *Journal of Clinical and Experimental Neuropsychology*, *27*(6), 690–699. https://doi.org/10.1080/13803390490918499

Kavé, G., Heled, E., Vakil, E., & Agranov, E. (2011). Which verbal fluency measure is most useful in demonstrating executive deficits after traumatic brain injury? *Journal of Clinical and Experimental Neuropsychology*, *33*(3), 358–365. https://doi.org/10.1080/13803395.2010.518703

Kerr, C. (1995). Dysnomia following traumatic brain injury: An information-processing approach to assessment. *Brain Injury*, *9*(8), 777–796. https://doi.org/10.3109/02699059509008234

Khalil, M. S. (2010). Preliminary Arabic normative data of neuropsychological tests: The verbal and design fluency. *Journal of Clinical and Experimental Neuropsychology*, *32*(9), 1028–1035. https://doi.org/10.1080/13803391003672305

Kim, B. J., Lee, C. S., Oh, B. H., Hong, C. H., Lee, K. S., Son, S. J., Han, C., Park, M. H., Jeong, H. G., Kim, T. H., Park, J. H., & Kim, K. W. (2013). A normative study of lexical verbal fluency in an educationally diverse elderly population. *Psychiatry Investigation*, *10*(4), 346–351. https://doi.org/10.4306/pi.2013.10.4.346

Kim, H., Kim, J., Kim, D. Y., & Heo, J. (2011). Differentiating between aphasic and nonaphasic stroke patients using semantic verbal fluency measures with administration time of 30 seconds. *European Neurology*, *65*(2), 113–117. https://doi.org/10.1159/000324036

Kim, H., & Na, D. L. (2004). Normative data on the Korean version of the Western Aphasia Battery. *Journal of Clinical and Experimental Neuropsychology*, *26*(8), 1011–1020. https://doi.org/10.1080/13803390490515397

Kosmidis, M., Vlahou, C., Panagiotaki, P., & Kiosseoglou, G. (2004). The verbal fluency task in the Greek population: Normative data, and clustering and switching strategies. *Journal of the International Neuropsychological Society*, *10*(2), 164–172. https://doi.org/10.1017/S1355617704102014

Kroenke, K., Spitzer, R. L., & Williams, J. B. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine*, *16*(9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2005). *Applied linear statistical models* (5th ed.). McGraw Hill.

Labos, E., Trojanowski, S., del Rio, M., Zabala, K., & Renato, A. (2013). Verbal fluency profiles in Argentina. Characterization and norms in extended time. *Neurología Argentina*, *5*(2), 78–86. https://doi.org/10.1016/j.neuarg.2013.04.005

Laine, M., Vuorinen, E., & Rinne, J. O. (1997). Picture naming deficits in vascular dementia and Alzheimer's disease. *Journal of Clinical and Experimental Neuropsychology*, *19*(1), 126–140. https://doi.org/10.1080/01688639708403842

Lee, T. M. C., Yuen, K. S. L., & Chan, C. C. H. (2002). Normative data for neuropsychological measures of fluency, attention, and memory measures for Hong Kong Chinese. *Journal of Clinical and Experimental Neuropsychology*, *24*(5), 615–632. https://doi.org/10.1076/jcen.24.5.615.1001

Lezak, M. D., Howieson, D. B., Bigler, E. D., & Tranel, D. (2012). *Neuropsychological assessment* (5th ed.). Oxford University Press.

Lezak, M. D., Howieson, D. B., Loring, D. W., & Fischer, J. S. (2004). *Neuropsychological assessment* (4th ed.). Oxford University Press.

Loonstra, A. S., Tarlow, A. R., & Sellers, A. H. (2001). COWAT metanorms across age, education, and gender. *Applied Neuropsychology*, *8*(3), 161–166. https://doi.org/10.1207/S15324826AN0803_5

Loring, D. W., Strauss, E., Hermann, B. P., Barr, W. B., Perrine, K., Trenerry, M. R., Chelune, G., Westerveld, M., Lee, G. P., Meador, K. J., & Bowden, S. C. (2008). Differential neuropsychological test sensitivity to left temporal lobe epilepsy. *Journal of the International Neuropsychological Society*, *14*(03), 394–400. https://doi.org/10.1017/S1355617708080582

Lucas, J. A., Ivnik, R. J., Smith, G. E., Bohac, D. L., Tangalos, E. G., Graff-Radford, N. R., & Petersen, R. C. (1998). Mayo's older Americans normative studies: Category fluency norms. *Journal of Clinical and Experimental Neuropsychology*, *20*(2), 194–200. https://doi.org/10.1076/jcen.20.2.194.1173

Lucas, J. A., Ivnik, R. J., Smith, G. E., Ferman, T. J., Willis, F. B., Petersen, R. C., & Graff-Radford, N. R. (2005). Mayo's Older African Americans normative studies: Norms for Boston Naming Test, Controlled Oral Word Association, Category Fluency, Animal Naming, Token Test, WRAT-3 Reading, Trail Making Test, Stroop Test, and Judgment of Line Orientation. *The Clinical Neuropsychologist*, *19*(2), 243–269. https://doi.org/10.1080/13854040590945337

Lukatela, K., Malloy, P., Jenkins, M., & Cohen, R. (1998). The naming deficit in early Alzheimer's and vascular dementia. *Neuropsychology*, *12*(4), 565–572. https://doi.org/10.1037/0894-4105.12.4.565

Machado, T. H., Fichman, H. C., Santos, E. L., Carvalho, V. A., Fialho, P. P., Koenig, A. M., Fernandes, C. S., Lourenço, R. A., Paradela, E., & Caramelli, P. (2009). Normative data for healthy elderly on the phonemic verbal fluency task - FAS. *Dementia & Neuropsychologia*, *3*(1), 55–60. https://doi.org/10.1590/S1980-57642009DN30100011

Mack, W. J., Teng, E., Zheng, L., Paz, S., Chui, H., & Varma, R. (2005). Category fluency in a latino sample: Associations with age, education, gender, and language. *Journal of Clinical and Experimental Neuropsychology*, *27*(5), 591–598. https://doi.org/10.1080/13803390490918417

Mahoney, F. I., & Barthel, D. (1965). Functional evaluation: The Barthel Index. *Maryland State Medical Journal*, *14*, 56–61.

Mariën, P., Mampaey, E., Vervaet, A., Saerens, J., & De Deyn, P. P. (1998). Normative data for the Boston naming test in native Dutch-speaking Belgian elderly. *Brain and Language*, *65*(3), 447–467. https://doi.org/10.1006/brln.1998.2000

Mathuranath, P. S., George, A., Cherian, P. J., Alexander, A. L., Sarma, S. G., & Sarma, P. S. (2003). Effects of age, education and gender on verbal fluency. *Journal of Clinical and Experimental Neuropsychology*, *25*(8), 1057–1064. https://doi.org/10.1076/jcen.25.8.1057.16736

McDowd, J., Hoffman, L., Rozek, E., Lyons, K. E., Pahwa, R., Burns, J., & Kemper, S. (2011). Understanding verbal fluency in healthy aging, Alzheimer's disease, and Parkinson's disease. *Neuropsychology*, *25*(2), 210–225. https://doi.org/10.1037/a0021531

Miotto, E., Sato, J., Lucia, M., Camargo, C., & Scaff, M. (2010). Development of an adapted version of the Boston Naming Test for Portuguese speakers. *Revista Brasileira de Psiquiatria*, *32*(3), 279–282. https://doi.org/10.1590/s1516-44462010005000006

Mitrushina, M., Boone, K. B., Razani, J., & D'Elia, L. F. (2005). *Handbook of normative data for neuropsychological assessment* (2nd ed.). Oxford University Press.

Morgado, J., Rocha, C. S., Maruta, C., Guerreiro, M., & Martins, I. P. (2009). Novos valores normativos do mini-mental state examination. *Sinapse*, *9*(2), 10–16.

Neils, J., Baris, J. M., Carter, C., Dell'aira, A. L., Nordloh, S. J., Weiler, E., & Weisiger, B. (1995). Effects of age, education, and living environment on Boston Naming Test performance. *Journal of Speech and Hearing Research*, *38*(5), 1143–1149. https://doi.org/10.1044/jshr.3805.1143

Olabarrieta-Landa, L., Rivera, D., Galarza-del-Angel, J., Garza, M. T., Saracho, C. P., Rodríguez, W., Chávez-Oliveros, M., Rábago, B., Leibach, G., Schebela, S., Martínez, C., Luna, M., Longoni, M., Ocampo-Barba, N., Rodríguez, G., Aliaga, A., Esenarro, L., García de la Cadena, C., Perrin, B. P., & Arango-Lasprilla, J. C. (2015). Verbal fluency tests: Normative data for the Latin American Spanish speaking adult population. *NeuroRehabilitation*, *37*(4), 515–561. https://doi.org/10.3233/NRE-151279

Olabarrieta-Landa, L., Rivera, D., Morlett-Paredes, A., Jaimes-Bautista, A., Garza, M. T., Galarza-del-Angel, J., Rodríguez, W., Rábago, B., Schebela, S., Perrin, P. B., Luna, M., Longoni, M., Ocampo-Barba, N., Aliaga, A., Saracho, C. P., Bringas, M. L., Esenarro, L., García-Egan, P., & Arango-Lasprilla, J. C. (2015). Standard form of the Boston Naming Test: Normative data for the Latin American Spanish speaking adult population. *NeuroRehabilitation*, *37*(4), 501–513. https://doi.org/10.3233/NRE-151278

Olabarrieta-Landa, L., Rivera, D., Vergara Torres, G. P., Lozano Plaza, J. E., Quijano, M. C., De los Reyes Aragón, C. J., Utria Rodríguez, O. E., Medina Salcedo, M., Perrin, P. B. & Arango-Lasprilla , (2015). Datos normativos del Test de Fluidez Verbal Semántica y Fonológica para población Colombiana. In J. C., Arango Lasprilla, & D., Rivera (Eds.), *Neuropsicología en Colombia: Datos normativos, estado actual y retos a futuro* (pp. 178–207). Universidad Autónoma de Manizales.

Ostrosky-Solís, F., Ramírez, M., Lozano, A., Picasso, H., & Vélez, A. (2004). Culture or education? Neuropsychological test performance of a Maya indigenous population. *International Journal of Psychology*, *39*(1), 36–46. https://doi.org/10.1080/00207590344000277

Park, J., Lee, G., Lee, S. U., & Jung, S. H. (2016). The impact of acute phase domain-specific cognitive function on post-stroke functional recovery. *Annals of Rehabilitation Medicine*, *40*(2), 214. https://doi.org/10.5535/arm.2016.40.2.214

Patterson, J. (2011). Verbal fluency. In J. S. Kreutzer, J. DeLuca, & B. Caplan (Eds.), *Encyclopedia of clinical neuropsychology* (pp. 2603–2606). Springer.

Peña-Casanova, J., Blesa, R., Aguilar, M., Gramunt-Fombuena, N., Gómez-Ansón, B., Oliva, R., Molinuevo, J. L., Robles, A., Barquero, M. S., Antúnez, C., Martínez-Parra, C., Frank-García, A., Fernández, M., Alfonso, V., & Sol, J. (2009). Spanish multicenter normative studies (NEURONORMA project): Methods and sample characteristics. *Archives of Clinical Neuropsychology*, *24*(4), 307–319. https://doi.org/10.1093/arclin/acp027

Phillips, T. J., James, A. C. D., Crow, T. J., & Collinson, S. L. (2004). Semantic fluency is impaired but phonemic and design fluency are preserved in early-onset schizophrenia. *Schizophrenia Research*, *70*(2–3), 215–222. https://doi.org/10.1016/j.schres.2003.10.003

Quijano, M. C., Olabarrieta-Landa, L., Rivera, D., Valdivia Tangarife, E. R., Vergara Torres, G. P., De los Reyes Aragón, C. J., Utria Rodríguez, O. E., Medina Salcedo, M., Perrin, P. B. & Arango-Lasprilla , (2015). Datos normativos del Test de Denominación de Boston para población Colombiana. In J. C., Arango-Lasprilla, & D., Rivera (Eds.), *Neuropsicología en Colombia: Datos normativos, estado actual y retos a futuro* (pp. 209–222). Universidad Autónoma de Manizales.

Quinones-Ubeda, S., Pena-Casanova, J., Böhm, P., Gramunt-Fombuena, N., & Comas, L. (2004). Preliminary normative data for the second edition of the Boston Naming Test for young Spanish adults. *Neurología*, *19*(5), 248–253.

R Development Core Team. (2020). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing.

Rabin, L. A., Barr, W. B., & Burton, L. A. (2005). Assessment practices of clinical neuropsychologists in the United States and Canada: A survey of INS, NAN, and APA Division 40 members. *Archives of Clinical Neuropsychology*, *20*(1), 33–65. https://doi.org/10.1016/j.acn.2004.02.005

Rami, L., Serradell, M., Bosch, B., Caprile, C., Sekler, A., Villar, A., Canal, R., & Molinuevo, J. L. (2008). Normative data for the Boston Naming Test and the Pyramids and Palm Trees Test in the elderly Spanish population. *Journal of Clinical and Experimental Neuropsychology*, *30*(1), 1–6. https://doi.org/10.1080/13803390701743954

Raskin, S. A., & Rearick, E. (1996). Verbal fluency in individuals with mild traumatic brain injury. *Neuropsychology*, *10*(3), 416–422. https://doi.org/10.1037/0894-4105.10.3.416

Rivera, D., Olabarrieta-Landa, L., Van der Elst, W., Gonzalez, I., Ferrer-Cascales, R., Peñalver Guia, A. I., Rodriguez-Lorenzana, A., Galarza-del-Angel, J., Irías Escher, M. J., & Arango-Lasprilla, J. C. (2020). Regression-based normative data for children from Latin America: Phonological verbal fluency letters M, R, and P. *Assessment*. Advance online publication. https://doi.org/10.1177/1073191119897122.

Rivera, D., Olabarrieta-Landa, L., Van der Elst, W., Gonzalez, I., Rodríguez-Agudelo, Y., Aguayo Arelis, A., Rodriguez-Irizarry, W., García de la Cadena, C., & Arango-Lasprilla, J. C. (2019). Normative data for verbal fluency in healthy Latin American adults: Letter M, and fruits and occupations categories. *Neuropsychology*, *33*(3), 287–300. https://doi.org/10.1037/neu0000518

Ruff, R. M., Light, R. H., Parker, S. B., & Levin, H. S. (1997). The psychological construct of word fluency. *Brain and Language*, *57*(3), 394–405. https://doi.org/10.1006/brln.1997.1755

Ryu, S.-H., Kim, K. W., Kim, S., Park, J. H., Kim, T. H., Jeong, H.-G., Kim, J. L., Moon, S. W., Bae, J. N., Yoon, J. C., Choo, I. H., Lee, D. W., Chang, S. M., Jhoo, J. H., Kim, S.-K., & Cho, M. J. (2012). Normative study of the category fluency test (CFT) from nationwide data on community-dwelling elderly in Korea. *Archives of Gerontology and Geriatrics*, *54*(2), 305–309. https://doi.org/10.1016/j.archger.2011.05.010

Sauzéon, H., Lestage, P., Raboutet, C., N'Kaoua, B., & Claverie, B. (2004). Verbal fluency output in children aged 7-16 as a function of the production criterion: Qualitative analysis of clustering, switching processes, and semantic network exploitation. *Brain and Language*, *89*(1), 192–202. https://doi.org/10.1016/S0093-934X(03)00367-5

Steinberg, B. A., Bieliauskas, L. A., Smith, G. E., & Ivnik, R. J. (2005). Mayo's older Americans normative studies: Age-and IQ-adjusted norms for the Trail-Making Test, the Stroop Test, and MAE Controlled Oral Word Association Test. *The Clinical Neuropsychologist*, *19*(3–4), 329–377. https://doi.org/10.1080/13854040590945210

Steiner, V. A. G., Mansur, L. L., Brucki, S. M. D., & Nitrini, R. (2008). Phonemic verbal fluency and age: A preliminary study. *Dementia & Neuropsychologia*, *2*(4), 328–332. https://doi.org/10.1590/S1980-57642009DN20400017

Strauss, E., Sherman, E. M., & Spreen, O. (2006). *A compendium of neuropsychological tests: Administration, norms, and commentary* (3rd ed.). Oxford University Press.

Taler, V., & Phillips, N. A. (2008). Language performance in Alzheimer's disease and mild cognitive impairment: A comparative review. *Journal of Clinical and Experimental Neuropsychology*, *30*(5), 501–556. https://doi.org/10.1080/13803390701550128

Tallberg, I. M. (2005). The Boston naming test in Swedish: Normative data. *Brain and Language*, *94*(1), 19–31. https://doi.org/10.1016/j.bandl.2004.11.004

Tallberg, I. M., Ivachova, E., Jones Tinghag, K., & Östberg, P. (2008). Swedish norms for word fluency tests: FAS, animals and verbs. *Scandinavian Journal of Psychology*, *49*(5), 479–485. https://doi.org/10.1111/j.1467-9450.2008.00653.x

Thompson, P. J., & Duncan, J. S. (2005). Cognitive decline in severe intractable epilepsy. *Epilepsia*, *46*(11), 1780–1787. https://doi.org/10.1111/j.1528-1167.2005.00279.x

Tombaugh, T. N., & Hubley, A. (1997). The 60-item Boston Naming Test: Norms for cognitively intact adults aged 25 to 88 years. *Journal of Clinical and Experimental Neuropsychology*, *19*(6), 922–932. https://doi.org/10.1080/01688639708403773

Tombaugh, T. N., Kozak, J., & Rees, L. (1999). Normative data stratified by age and education for two measures of verbal fluency: FAS and animal naming. *Archives of Clinical Neuropsychology*, *14*(2), 167–177. https://doi.org/10.1093/arclin/14.2.167

Tsolaki, M., Tsantali, E., Lekka, S., Kiosseoglou, G., & Kazis, A. (2003). Can the Boston Naming Test be used as a clinical tool for differential diagnosis in dementia? *Brain and Language*, *87*(1), 185–186. https://doi.org/10.1016/S0093-934X(03)00262-1

Van Breukelen, G. J., & Vlaeyen, J. W. (2005). Norming clinical questionnaires with multiple regression: The pain cognition list. *Psychological Assessment*, *17*(3), 336–344. https://doi.org/10.1037/1040-3590.17.3.336

Van der Elst, W., Van Boxtel, M. P., & Jolles, J. (2012). Occupational activity and cognitive aging: A case-control study based on the Maastricht Aging Study. *Experimental Aging Research*, *38*(3), 315–329. https://doi.org/10.1080/0361073X.2012.672137

Van Der Elst, W., Van Boxtel, M. P., Van Breukelen, G. J., & Jolles, J. (2006). Normative data for the Animal, Profession and Letter M Naming verbal fluency tests for Dutch speaking participants and the effects of age, education, and sex. *Journal of the International Neuropsychological Society*, *12*(1), 80–89. https://doi.org/10.1017/S1355617706060115

Villodre, R., Sánchez-Alfonso, A., Brines, L., Núñez, A. B., Chirivella, J., Ferri, J., & Noé, E., (2006). Fluencia verbal: Estudio normativo piloto según estrategias de "agrupación" y "saltos" de palabras en población española de 20 a 49 años. *Neurología*, *21*(3), 124–130.

Waldrop-Valverde, D., Ownby, R. L., Jones, D. L., Sharma, S., Nehra, R., Kumar, A. M., Prabhakar, S., & Kumar, M. (2015). Neuropsychological test performance among healthy persons in northern India: Development of normative data. *Journal of Neurovirology*, *21*(4), 433–438. https://doi.org/10.1007/s13365-015-0332-4

Wall, K. J., Cumming, T. B., & Copland, D. A. (2017). Determining the association between language and cognitive tests in poststroke aphasia. *Frontiers in Neurology*, *8*, 149. https://doi.org/10.3389/fneur.2017.00149

Weiss, E., Kemmler, G., Deisenhammer, E. A., Fleischhacker, W. W., & Delazer, M. (2003). Sex differences in cognitive functions. *Personality and Individual Differences*, *35*(4), 863–875. https://doi.org/10.1016/S0191-8869(02)00288-X

Weiss, E. M., Ragland, J. D., Brensinger, C. M., Bilker, W. B., Deisenhammer, E. A., & Delazer, M. (2006). Sex differences in clustering and switching in verbal fluency tasks. *Journal of the International Neuropsychological Society*, *12*(4), 502–509. https://doi.org/10.1017/s1355617706060656

Whiteside, D. M., Kogan, J., Wardin, L., Phillips, D., Franzwa, M. G., Rice, L., Basso, M., & Roper, B. (2015). Language-based embedded performance validity measures in traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, *37*(2), 220–227. https://doi.org/10.1080/13803395.2014.1002758

Williams, M. N., Grajales, C. A. G., & Kurkiewicz, D. (2013). Assumptions of multiple regression: Correcting two misconceptions. *Practical Assessment, Research, and Evaluation*, *18*(1), 1–14. https://doi.org/10.7275/55hn-wk47

Worrall, L. E., Yiu, E. M.-L., Hickson, L. M. H., & Barnett, H. M. (1995). Normative data for the Boston naming test for Australian elderly. *Aphasiology*, *9*(6), 541–551. https://doi.org/10.1080/02687039508248713

Zanin, L., Ledezma, C., Galarsi, M. F., & De Bortoli, M. A. (2010). Fluidez verbal en una muestra de 227 sujetos de la región Cuyo (Argentina). *Fundamentos en Humanidades*, *1*(21), 207–219. http://fundamentos.unsl.edu.ar/pdf/revista-21.pdf

Zarino, B., Crespi, M., Launi, M., & Casarotti, A. (2014). A new standardization of semantic verbal fluency test. *Neurol Sci*, *35*(9), 1405–1411. https://doi.org/10.1007/s10072-014-1729-1

Zec, R. F., Burkett, N. R., Markwell, S. J., & Larsen, D. L. (2007a). A cross-sectional study of the effects of age, education, and gender on the Boston Naming Test. *The Clinical Neuropsychologist*, *21*(4), 587–616. https://doi.org/10.1080/13854040701220028

Zec, R. F., Burkett, N. R., Markwell, S. J., & Larsen, D. L. (2007b). Normative data stratified for age, education, and gender on the Boston Naming Test. *The Clinical Neuropsychologist*, *21*(4), 617–637. https://doi.org/10.1080/13854040701339356

Zimmermann, N., Parente, M. A. D. M. P., Joanette, Y., & Fonseca, R. P. (2014). Unconstrained, phonemic and semantic verbal fluency: Age and education effects, norms and discrepancies. *Psicologia: Reflexão e Crítica*, *27*(1), 55–63. https://doi.org/10.1590/S0102-79722014000100007