OXFORD UNIVERSITY PRESS | Archives of Clinical Neuropsychology

# Verbal fluency tasks: influence of age, gender, and education and normative data for the Spanish native adult population



| | |
|---|---|
| Journal: | *Archives of Clinical Neuropsychology* |
| Manuscript ID | ACNP-2021-010.R1 |
| Manuscript Type: | Original Empirical Article |
| Keyword: | Elderly/Geriatrics/Aging, Cross-cultural/minority, Assessment, Norms/normative studies, Fluency (verbal/nonverbal) |
| | |



SCHOLARONE™
Manuscripts

**Abstract**

Objective: Phonological and semantic verbal fluency (VF) tasks are frequently used to assess language and executive functions in both clinical and research settings. F, A, and S are the most commonly used letters in phonological tasks across languages and cultures. Unfortunately, the lack of norms for the native Spanish population for these letters, and for certain semantic categories such as "proper names", may lead to misinterpretation of scores due to demographic differences. The aim of the present study was to provide normative data for F, A, and S, and for "proper names", "animals", and "fruits and vegetables" for the native Spanish population. Method: 257 healthy subjects took part in the study (ageing 17-100 years, 3-20 years of education). Correlation, multiple regression and t-tests were used to select the most appropriate variables for stratification. Results: Education was the best predictor of performance in all tasks, followed by age. Given that t-test results showed no differences related to gender, with the only exception of the semantic category "animals", this variable was not considered for stratification. Consequently, the data was stratified in two education levels (<13, ≥13 years of education) and in two age levels (<60, ≥60) within the low educational level group. Mean, standard deviation and percentile scores for each group are provided. Conclusions: The present norms provide a reference for clinicians assessing VF. This data may also facilitate comparisons with other normative studies in cross-cultural and cross-linguistic research.

**Key words:** verbal fluency; normative data; aging; cross-cultural; assessment.

For Peer Review

## Introduction

Verbal fluency (VF) tasks require individuals generate words under restricted lexical access conditions and within a fixed timeframe (Kraan, Stolwyk, & Testa, 2013; Strauss, Sherman, & Spreen, 2006). The most common type of tasks are phonological and semantic VF tasks, in which participants are asked to produce words that begin with certain letter or words that belong to a semantic category, respectively (Strauss et al., 2006). Standardized measures of VF have been extensively used in clinical neuropsychological settings, as well as in research studies about cognitive impairment in neurological and psychiatric populations (Henry, 2006; Henry & Beatty, 2006; Henry & Crawford, 2004; 2005; Raucher-Chéné, Achim, Kaladjian, & Besche-Richard, 2017; Wyman-Chick, 2016). These tasks do not require special equipment to perform them, which make them easy and quick to administer (Lezak, Howieson, Bigler, & Tranel, 2012, p. 693; Stolwyk, Bannirchelvam, Kraan, & Simpson, 2015). They are also highly indicative of brain dysfunction (Lezak et al., 2012) and are used to analyse deficits in language functions (i.e., naming, or extent of vocabulary), response speed, mental organization, search strategies, as well as short and long-term memory (Luo, Luk, & Bialystok, 2010; Ruff, Light, Parker, & Levin, 1997; Shao, Janse, Visser, & Meyer, 2014). At the cognitive level, they have been associated with executive functions, attention and alertness, lexical access and semantic storage, retrieval mechanisms, and working memory (Bose, Wood, & Kiran, 2017; Luo, Luk, & Bialystok, 2010).

Previous studies have identified associations between VF and demographic variables such as age (Chávez-Oliveros et al., 2015; Olabarrieta-Landa et al., 2015; Tallberg, Ivachova, Jones Tinghag, & Ostberg, 2008; Van der Elst, Van Boxtel, Van

For Peer Review

Breukelen, & Jolles, 2006), education (Hankee et al., 2013; Machado et al., 2009; Olabarrieta-Landa et al., 2015), and gender (Capitani, Laiacona, & Basso, 1998; Loonstra, Tarlow, & Sellers, 2001; Van der Elst, 2006). Generally, elderly people tend to score worse than younger, and low-educated people worse than high-educated ones (Strauss et al., 2006). Regarding gender, the direction of the influence is not clear: in some studies, a better performance has been found in women (Loonstra et al., 2001), but also a better performance of one gender over the other has been found depending on the VF category (e.g., Van der Elst et al., 2006). Similarly, studies have shown differences in VF based on ethnicity (Gladjso et al., 1999; Johnson-Selfridge, Zalewski, & Abourdarham, 1998), language (Buré-Reyes et al., 2013; Steenhuis & Ostbye, 1995), bilingualism (Rosselli, Ardila, Salvatierra, Marquez, Matos, & Weekes, 2002), and geographic region (Fillenbaum, Heyman, Huber, Gangull, & Unverzagt, 2001). Therefore, given the widespread use of VF tasks, the development of norms based on socio-demographic, cultural, and geographic factors should, at least, explore the influence of education, age and gender in order to provide useful data for clinical practice and research.

The FAS test is the most commonly used test in the assessment of phonological VF (Olabarrieta-Landa et al., 2017; Strauss et al., 2006; Tallberg et al., 2008). It was first developed by Benton as part of the Neurosensory Center Examination for Aphasia and normed for English speaking populations (Spreen & Benton, 1977). Its generalized use in psychological assessment has led to the publication of a great deal of normative data for children and adults of varying ages and education levels, speaking different languages, from different countries, and considering different ethnic and geographical factors (Carvalho & Caramelli, 2020; Esteves et al., 2005;

For Peer Review

Loonstra et al., 2001; Machado et al., 2009; Strauss et al., 2006; Tombaugh, Kozak, & Rees, 1999; Zimmermann, Parente, Joanette, & Fonseca, 2014). Unfortunately, the FAS has not been adequately standardized for the Spanish native population yet, the two existing set of norms having some remarkable issues (Buriel, Gramunt, Bohm, Rodes, & Pena-Casanova, 2004; Villodre et al., 2006). Firstly, both studies have a limited age range (20-49 years old) which does not include those over the age of 50. The lack of norms for older people considerably limits the applicability of VF tasks in increasingly relevant fields such as healthy aging and diseases which are significantly more prevalent with age (e.g., cerebral stroke, Alzheimer's, Parkinson's, etc; Corrada, Brookmeyer, Paganini-Hill, Berlau, & Kawas, 2010; García-Ramos, López Valdés, Ballesteros, Jesús, & Mir, 2016; Kelly-Hayes, 2010). Secondly, the small sample size of Villodre et al.'s study (N=53) stratified into two education groups (< 12, > 12 years of education) was below the minimum of 50 cases in each group recommended by Mitrushina, Boone, Razani, & D'Elia (2005). This limitation could undermine the utility of these norms given that data based on small sample sizes are highly influenced by individual differences and do not provide a reliable estimate of the population mean (Mitrushina et al., 2005). Moreover, in Buriel et al.'s study (2004), neither the stratification procedure nor the means and standard deviations of scores from each group were reported. In contrast to the situation for the Spanish native population, appropriate normative data for the FAS test have been provided for Spanish speaking populations from Argentina, Bolivia, Chile, Cuba, El Salvador, Guatemala, Honduras, Mexico, Paraguay, Peru, and Puerto Rico (Chávez-Oliveros et al., 2015; Olabarrieta-Landa et al., 2015; Pontón et al., 1996). Alternative VF tests using different letters (for example, M, P, and R) have been developed for native Spanish populations (Casals-

For Peer Review

Coll et al., 2013; Peña Casanova et al., 2009). Unfortunately, while F, A, and S letters from the original English version have revealed preliminary clues about compatibility with the Spanish version (Rosselli et al., 2002), data supporting the compatibility of alternative letters and the original FAS test is not yet available. In any case, neither the FAS version nor the MPR version have been validated in Spanish, which would permit an analysis of the potential equivalence of the test between different cultures.

Regarding semantic VF tasks, normative data for Spaniards has been provided for the categories "animals" (e.g., Casals-Coll et al., 2013; Contador et al., 2016) and "fruits and vegetables" (e.g., Casals-Coll et al., 2013; Contador et al., 2016). However, no norms are available for the semantic category "proper names", even while the use of this category has been reported in other languages and cultures (Mitrushina et al., 2005; Strauss et al., 2006).

Consequently, the aim of the present research was to provide a new set of norms for the Spanish native adult population for the phonological categories F, A, and S letters, as well as for the semantic categories "proper names", along with data for the "animals" and "fruits/vegetables" semantic categories, improving the existing data. The lack of an adequate set of norms for Spanish native people hinders the neuropsychologists' interpretation of individual patient scores in identifying the presence of pathological performance in clinical practise (Mitrushina et al., 2005; Strauss et al., 2006).

For Peer Review

## Materials and methods

### *Participants*

A total of 257 healthy subjects (90 men and 167 women) took part in the study. They were recruited from among undergraduate students, university staff, social organizations, hospitals, and health care centres from 9 different cities in Spain (Sevilla, Córdoba, Valencia, Barcelona, Ávila, Toledo, Málaga, Bilbao and Madrid). All the participants were selected according to the following criteria: a) to be born and currently living in Spain; b) to speak Spanish as their native language; c) to be monolingual (self-reported); d) to be free of any medical conditions, psychiatric disorders, substance abuse (excluding nicotine), or diagnosed neurological disease. Participants older than 49 had to meet two additional criteria: a) scoring ≥ 24 on the Mini-Mental State Examination (MMSE, Folstein, Folstein, & McHugh, 1975; Lobo et al., 1995); b) scoring < 5 on the short version of the Geriatric Depression Scale (Martínez de la Iglesia, 2002; Sheikh & Yesavage, 1986). All participants were fully informed about the aims of the research prior to the psychological evaluation session and signed a consent form according to the Declaration of Helsinki. This study was conducted in compliance with institutional research standards for human research and received the approval of the ethical committee of the institution.

### *Procedures*

For the present study, phonological and semantic VF tasks were applied. Each test consisted of the participant producing as many words as possible beginning with a certain letter (F, A, S) or belonging to a particular semantic category (animals, fruits and vegetables, proper names) within 60 seconds. Participants were told to

For Peer Review

avoid augmentatives, diminutives, and proper names (except for the "proper names" semantic task). Variations in the same word, intrusions, and repeated attempts were not taken into account. The total score consisted of the number of correct answers for each letter or category. The combined scores for Phonological VF (sum of F, A, and S scores) and Semantic VF (sum of animals, fruits/vegetables, and proper names scores) were also considered. Descriptive statistics for age, education, gender, and each VF scores are presented in Table 1.

[INSERT TABLE 1 ABOUT HERE]

*Statistical Analysis*

Independent sample t-tests and correlation analyses were carried out for dichotomous and continuous variables, respectively, to explore the most appropriate variables for stratification. In a further step, regression analyses were used to decide which demographic variables could represent the best criteria for data stratification. A series of t-tests were performed on the dependent measures in order to decide the number of useful set of norms to be considered. A significance level of .05 was set for all main contrasts. Finally, scores from the resulting groups were transformed into percentile scores. The SPSS statistical software package, version 22.0, was used for all analyses. Effects sizes for all contrasts were calculated with G*Power 3.1 statistical software (Faul, Erdfelder, Buchner, & Lang, 2009).

## Results

*Between- group comparisons*

For Peer Review

Regarding the effect of gender, the t-tests showed no significant differences between men and women in any of the VF scores (F: t(255) = -.2; $p$ = .854); A: t(255) = -1; $p$ = .32); S: t(255) = -.9; $p$ = .393; fruits and vegetables: t(255)= -.02; $p$= .984; proper names: t(255) = .5; $p$ = .627; Phonological VF: t(255) = -.8; $p$ = .45; Semantic VF: t(255) = -.8; $p$ = .432), except for the animals semantic category (t(255) = -2.4; $p$ = .016; $d$ = .3), where men scored higher than women. Thus, gender was not considered for stratification.

*Correlation and Regression analyses*

Correlations among the demographic variables and the VF scores provided an approach for the selection of stratification variables. Age was negatively correlated with all the VF scores ($p$ < .01 in all cases), whereas education correlated positively ($p$ < .01 in all cases; see Table 2). Multiple regression analyses were carried out to evaluate the relative contribution of age and education to VF scores (see Table 3). Taken together, age and education were significant predictors of all the VF variables ($p$ < .001 in all cases). They jointly accounted for 31.9% of variance of F score ($f^2$ = .5), 34.2% of A score ($f^2$ = .5), 35.5% of S score ($f^2$ = .6), 45.4% of animals score ($f^2$ = .8), 34.4% of fruits and vegetables score ($f^2$ = .5), 41.8% of proper names score ($f^2$ = .7), 41% of Phonological VF score ($f^2$ = .7), and 49.8% of Semantic VF score ($f^2$ =1). An examination of partial correlations from multiple regressions revealed a significant contribution of both education and age to all the VF scores (except for F and fruits and vegetables in the case of age; see Table 3). Accordingly, both variables were considered for stratification.

[INSERT TABLE 2 and 3 ABOUT HERE]

For Peer Review

*Stratification*

First, the sample was divided into two education groups according to percentile 50: low levels of education (< 13 years of education) and high levels of education (>= 13 years of education; see Table 4 for descriptive statistics). The two groups differed in all the VF variables (F: t (255) = -9.6; $p < .001$; $d = 1.2$; A: t (221) = -9.1; $p < .001$; $d = 1.2$; S: t (255) = -8.2; $p < .001$; $d = 1$; animals: t (255) = -12.6; $p < .001$; $d = 1.6$; fruits and vegetables: t (255) = -10.4; $p < .001$; $d = 1.3$; proper names: t (255) = -10; $p < .001$; $d = 1.2$; Phonological VF: t (-10.3) = ; $p < .001$; $d = 1.3$; Semantic VF: t (-12.9) = -; $p < .001$; $d = 1.6$), with participants in the high education group obtaining better scores. Second, each education group was divided into two age groups using a cut-off of 60 years of age. The choice of this cut-off was supported by data from the studies showing that performance in VF tasks starts to decline around this age (e.g., Tombaugh at al., 1999). In this way the following four education/age groups were obtained: low education-young, low education-old, high education-young, and high education-old. In the low education group, young participants outperformed older ones in all the VF variables (F: t (110) = 5.4; $p < .001$; $d = .9$; A: t (106) = 7; $p < .001$; $d = 1.2$; S: t (102) = 7.8; $p < .001$; $d = 1.4$; animals: t (140) = 10.1; $p < .001$; $d = 1.7$; fruits and vegetables: t (140) = 5.9; $p < .001$; $d = .9$; proper names: t (110) = 9; $p < .001$; $d = 1.5$; Phonological VF: t (97) = 8; $p < .001$; $d = 1.4$; Semantic VF: t (104) = 9.7; $p < .001$; $d = 1.7$). On the contrary, in the high education group, young participants outperformed older ones in only the proper names semantic category (young participants: 27.9±6.5, old participants: 22.8±4.7; t (113) = 3; p = .003; d = .9) and in the total Semantic VF scores (young participants: 72.3±12.9, old participants: 65.1±12.8; t (113) = 2.1; $p = .036$; $d = .6$). Accordingly, only the low education group was divided into two age groups for the



For Peer Review

stratification of norms. Table 4 shows the descriptive statistics (mean, standard deviation, maximum, minimum) for age, education, and the VF variables in the low education-young, low education-old, and high education groups. Tables 5 and 6 provide normative data for the VF scores stratified by education and age (in the low education group).

[INSERT TABLE 4 and 5 ABOUT HERE]

**Discussion**

Appropriate normative data of VF tasks have been provided for several adult Spanish-speaking populations (Chávez-Oliveros et al., 2015; Olabarrieta-Landa et al., 2015) but, taking into account the potential influence of cultural and geographic factors in VF tasks (Buré-Reyes et al., 2013; Fernández & Abe, 2017; González, Mungas, & Haan, 2005; Ostrosky-Solis, Gutierrez, Flores, & Ardila, 2007), specific norms for specific populations are required. The purpose of the present study was to provide norms for the native Spanish population in some of the most frequently used phonological and semantic VF tasks in experimental and clinical settings.

At least, three main features should be highlighted regarding the present data. First, this is the first normative study that includes a wide age range (17-100 years), providing data for F, A, and S letters for the Spanish population over 50 years of age. Second, the relatively large sample size allows data to be stratified by education and age, of at least 50 individuals as previously recommended (Mitrushina et al., 2005). Finally, means and standard deviations for tasks scores

For Peer Review

as well as percentile tables are provided for each group, thus facilitating comparability with other studies.

In line with the findings of previous studies (Contador et al., 2016; Olabarrieta-Landa et al., 2015; Peña-Casanova et al., 2009; Tombaugh et al., 1999), performance on VF tasks was significantly influenced by socio-demographic variables. The results of multiple regression analyses revealed that education and age together explained a significant amount of variance of all scores. Education was the best predictor of an individual's performance in both phonological and semantic tasks and was associated with higher scores. This is consistent with previous research where participants with more years of education scored higher on VF tasks (Benito-Cuadrado et al., 2002; Machado et al., 2009; Olabarrieta-Landa et al., 2015; Ostrosky-Solis et al., 2007; Strauss et al., 2006). As with education, age proved to be a significant predictor of performance in VF tasks, in line with previous research with both Spanish (Contador et al., 2016; Peña Casanova et al. 2009) and non-Spanish populations (Chávez-Oliveros et al., 2015; Olabarrieta-Landa et al., 2015). However, age accounted for smaller amount of variance in comparison with education, and its effect was not found for the F phonological task, or for the fruits and vegetables task. These results confirm the less pronounced effect of age compared to education, as described in previous literature (Casals-Coll et al., 2013; Olabarrieta-Landa et al., 2015), and suggest that this pattern is present in both phonological and semantic VF tasks. Furthermore, greater age was associated with poorer performance, confirming the results of most previous normative studies (Contador et al., 2016; Olabarrieta-Landa et al., 2015). In fact, when performance between young and old participants was

For Peer Review

compared within the low educational level group, the younger group outperformed the older group in all tasks. Meanwhile, in the high educational level group differences between young and old participants were found only in the proper name category and in the total Semantic VF scores. This seems to suggest that the age-related decline in VF performance is more evident in individuals with a low educational level, education being a protective factor in attenuating the effects of age in well-educated participants in accordance with the cognitive reserve hypothesis (Stern, 2009). However, the lack of significant differences among the high education group may also be related to the fact that higher education was much less accessible when the older cohort was at university age, thus favouring the university educated older adults compared to younger adults with same level of education. In the present work, gender did not have an influence on VF scores, except for the "animals" category. This is in line with the findings of previous studies which show that the impact of gender on phonological and semantic VF performance is inconsistent or absent (Gladsjo et al., 1999; Olabarrieta-Landa et al., 2015; Tombaugh et al., 1999). The minor male advantage in "animals" category is comparable with the results from other studies is comparable with the results of other studies (Contador et al., 2016; Marino & Alderete, 2010).

The present findings indicate that a clinically useful interpretation of VF task performance requires considering variables such as education and age. Thus, the present norms are a significant contribution to determining more precisely the degree of VF impairment among Spanish individuals. Given that VF deficits have been observed in several neurological and psychiatric populations (Tombaugh et

For Peer Review

al., 1999), this issue has important implications for both clinical and forensic settings, allowing a more precise description of patients. The norms provided here for people over 50 years of age are particularly useful given that, as a population gets older, age-related neurodegenerative diseases like Alzheimer's disease become more common (Johnson, 2015). Previous studies have indicated that changes in VF have been observed in people 3 to 5 years before clinical diagnosis of Alzheimer's disease. Thus, VF testing may be considered important predictors of subsequent development of Alzheimer's disease in older adults (Artero, Tierney, Touchab, & Ritchie, 2003; Backman, Jones, Berger, & Laukka, 2005; Saxton et al., 2004). Therefore, the availability of adequate norms to identify VF decline at its first signs has both diagnostic and predictive relevance. Moreover, selective impairment in phonological versus semantic VF has been found in a variety of neurological impairments, such as post-stroke aphasia, Alzheimer's disease, primary progressive aphasia, vascular dementia, and amyotrophic lateral sclerosis (Baldo, Schwartz, Wilkins, & Dronkers, 2006; Herrera, Cuetos, & Ribacoba, 2012; Hodges, Salmon, & Butters, 1992; Jones, Laukka, & Backman, 2006; Laws, Duncan, & Gale, 2010; Magaud et al., 2010; Quinn et al. 2012; Troyer, Moscovitch, Winocur, Leach, & Freedman, 1998). Providing norms for both phonological and semantic fluency derived from the same sample will allow neuropsychologists to determine if VF tasks are differentially affected, being this information useful for differential diagnosis purposes (Crossley, D'Arcy, & Rawson, 1997; Magaud et al., 2010; Vaughan, Coen, Kenny, & Lawlor, 2018). In addition, the available set of norms for the Spanish native population hinder comparability with other normative studies. Notably, they provide data for letters (M, P and R) that are not frequently used in research across other languages and cultures (Casals-Coll et al., 2013; Peña-

For Peer Review

Casanova et al., 2009) and do not report the mean and standard deviation of the scores within each age and education group (Buriel et al., 2004; Casals-Coll et al., 2013; Peña-Casanova et al., 2009). The present norms, using the most commonly used letter and semantic categories and overcoming the limitations of previous investigations, will favour the development of cross-cultural and cross-linguistic research for Spanish and non-Spanish speaking populations.

Two final considerations should be taken into account when using the present norms. First, they should not be used to evaluate non-Spanish native populations. Second, and given evidence suggesting that the number of words generated may vary by letters or categories (Tombaugh et al., 1999), the present norms will be only suitable when the letters F, A, and S or the category animals, fruits and vegetables, and proper names are used. Future research should address the potential effects of socio-demographic factors (i.e., such as occupation, socio-economic level, urban or rural living areas) and cognitive variables (i.e., reading and intellectual level) on performance in VF tasks (Contador et al., 2016; Strauss et al., 2006). Nevertheless, the present set of norms represents a substantial improvement over those previously published and will allow a more precise assessment of VF for clinicians and researchers.

For Peer Review

**Acknowledgements**

G. L-Z. was supported by a fellowship from the Fundación Tatiana Pérez de Guzman el Bueno.

For Peer Review

## References

Artero, A., Tierney, M. C., Touchab, J., & Ritchie, K. (2003). Prediction of transition form cognitive impairment to senile dementia: A prospective longitudinal study. *ACTA Psychiatrica Scandinavica, 107*, 390–393. doi:10.1034/j.1600-0447.2003.00081.x

Backman, L., Jones, S., Berger, A. K., & Laukka, E. J. (2005). Cognitive impairment in preclinical Alzheimer's disease: A meta-analysis. *Neuropsychology, 19*, 520–531. doi:10.1037/0894-4105.19.4.520

Baldo, J. V., Schwartz, S., Wilkins, D., & Dronkers, N. F. (2006). Role of frontal versus temporal cortex in verbal fluency as revealed by voxel-based lesion symptom mapping. *Journal of the International Neuropsychological Society, 12*, 896–900. doi:10.1017/S1355617706061078

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*, 1117–1122. doi:10.1076/jcen.24.8.1117.8376

Bose, A., Wood, R., & Kiran, S. (2017). Semantic fluency in aphasia: clustering and switching in the course of one minute. *International Journal of Language & Communication Disorders, 52*, 334-345. doi:10.1111/1460-6984.12276

Buré-Reyes A., Hidalgo-Ruzzante N., Vilar-Lopez R., Gontier J., Sanchez L., Perez-Garcia M., & Puente, A. E. (2013). Neuropsychological test performance of Spanish speakers: Is performance different across different Spanish-speaking groups? *Journal of Clinical and Experimental Neuropsychology, 35*, 404-412. doi:10.1080/13803395.2013.778232

For Peer Review

Buriel, Y., Gramunt, N., Bohm, P., Rodes, E., & Pena-Casanova, J. (2004). Verbal fluency: preliminary normative data in a Spanish sample of young adults (20–49 years of age). *Neurología*, *19*, 153–159.

Capitani, E., Laiacona, M., & Basso, A. (1998). Phonetically cued word-fluency, gender differences and aging: A reappraisal. *Cortex, 34*, 779–783. doi:10.1016/S0010-9452(08)70781-0

Carvalho, G. A., & Caramelli, P (2020). Normative Data for Middle-Aged Brazilians in Verbal Fluency (Animals and FAS), Trail Making Test (TMT) and Clock Drawing Test (CDT). *Dementia & Neuropsychologia, 14*, 14-23. doi:10.1590/1980-57642020dn14-010003

Casals-Coll, M., Sánchez-Benavides, G., Quintana, M., Manero, R. M., Rognoni, T., Calvo, L., … Peña Casanova, J. (2013). Spanish normative studies in young adults (NEURONORMA young adults project): norms for verbal fluency tests. *Neurología*, *28*, 33–40. doi:10.1016/j.nrleng.2012.02.003

Chávez-Oliveros, M., Rodríguez-Agudelo, Y., Acosta-Castillo, I., García-Ramírez, N., Rojas de la Torre, G., & Sosa-Ortiz, A. L. (2015). Semantic verbal fluency in elderly Mexican adults: reference values. *Neurología, 30*, 189–194. doi:10.1016/j.nrleng.2015.03.001

Contador, I., Almondes, K., Fernández-Calvo, B., Boycheva, E., Puertas-Martín, V., Benito-León, J., & Bermejo-Pareja, F. (2016). Semantic Verbal Fluency: Normative Data in Older Spanish Adults From NEDICES Population-Based Cohort. *Archives of Clinical Neuropsychology, 31*, 954-962. doi:10.1093/arclin/acw071

For Peer Review

Corrada, M. M., Brookmeyer, R., Paganini-Hill, A., Berlau, D., & Kawas, C. H. (2010). Dementia incidence continues to increase with age in the oldest old: the 90+ study. *Annals of Neurology, 67,* 114-21. doi:10.1002/ana.21915

Crossley, M., D'Arcy, C., & Rawson, N. S. B. (1997). Letter and category fluency in community-dwelling Canadian seniors: A comparison of normal participants to those with dementia of the Alzheimer or vascular type. *Journal of Clinical and Experimental Neuropsychology, 19*, 52–62. doi:10.1080/01688639708403836

Esteves, C. S., Oliveira, C. R., Moret-Tatay, C., Navarro-Pardo, E., De Carli, G. A., Silva, … Argimon. I. I. L. (2015). Phonemic and Semantic Verbal Fluency Tasks: Normative Data for Elderly Brazilians. *Psicologia: Reflexão e Crítica, 28*, 350-355. doi:10.1590/1678-7153.201528215

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*, 1149-1160. doi:10.3758/BRM.41.4.1149

Fernández, A. L., & Abe, J. (2017). Bias in cross-cultural neuropsychological testing: problems and possible solutions. *Culture and Brain*, *6*, 1–35. doi:10.1007/s40167-017-0050-2

Fillenbaum, G. G., Heyman, A., Huber, M. S., Gangull, M., & Unverzagt, F. W. (2001). Performance of elderly African American and white community residents on the CERAD neuropsychological battery. *Journal of the International Neuropsychological Society, 7*, 502–509. doi:10.1017/s1355617701744062

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*, 189–198. doi:10.1016/0022-3956(75)90026-6

For Peer Review

García-Ramos, R., López Valdés, E., Ballesteros, L., Jesús, S., & Mir, P. (2016). The social impact of Parkinson's disease in Spain: Report by the Spanish Foundation for the Brain. *Neurología, 31*, 401–413. doi: 10.1016/j.nrleng.2013.04.008

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*, 147–178. doi: 10.1177/107319119900600204

González, H.M., Mungas, D., & Haan, M. (2005). A semantic verbal fluency test for English- and Spanish-Speaking Older Mexican-Americans. *Archives of Clinical Neuropsychology, 20*, 199–208. doi:10.1016/j.acn.2004.06.001

Hankee, L. D., Preis, S. R., Beiser, A. S., Devine, S. A., Liu, Y., Seshadri, S., & Au, R. (2013). Qualitative Neuropsychological Measures: Normative Data on Executive Functioning Tests from the Framingham Offspring Study. *Experimental Aging Research, 39*, 515-535. doi:10.1080/0361073X.2013.839029

Henry, J. (2006). A Meta-Analytic Review of Wisconsin Card Sorting Test and Verbal Fluency Performance in Obsessive-Compulsive Disorder. *Cognitive Neuropsychiatry*, *11*, 156-176. doi:10.1080/13546800444000227

Henry, J. D., & Beatty, W. W. (2006). Verbal Fluency Deficits in Multiple Sclerosis. *Neuropsychologia, 44*, 1166-1174. doi:10.1016/j.neuropsychologia.2005.10.006

Henry, J. D., & Crawford, J. R. (2004). A meta-analytic review of verbal fluency performance in patients with traumatic brain injury. *Neuropsychology, 18,* 621-628. doi:10.1037/0894-4105.18.4.621

For Peer Review

Henry, J., & Crawford, J. R. (2005). A Meta-Analytic Review of Verbal Fluency Deficits in Depression. *Journal of Clinical and Experimental Neuropsychology, 27*, 78-101. doi:10.1080/138033990513654

Herrera, E., Cuetos, F., & Ribacoba, R. (2012). Verbal fluency in Parkinson's disease patients on/off dopamine medication. *Neuropsychologia, 50*, 3636-40. doi:10.1016/j.neuropsychologia.2012.09.016

Hodges, J. R., Salmon, D. P., & Butters, N. (1992). Semantic Memory impairment of Alzheimer's disease: Failure of access or degraded knowledge? *Neuropsychologia, 30*, 301–314. doi:10.1016/0028-3932(92)90104-t

Johnson I. P. (2015). Age-related neurodegenerative disease research needs aging models. *Frontiers in aging neuroscience, 7*, Article 168. doi:10.3389/fnagi.2015.00168

Johnson-Selfridge, M. T., Zalewski, C., & Abourdarham, J. F. (1998). The relationship between ethnicity and word fluency. *Archives of Clinical Neuropsychology, 13*, 319-325. doi:10.1093/arclin/13.3.319

Jones, S., Laukka, E. J., & Backman, L. (2006). Differential verbal fluency deficits in the preclinical stages of Alzheimer's disease and vascular dementia. *Cortex, 42*, 347–355. doi:10.1016/S0010-9452(08)70361-7

Kelly-Hayes, M. (2010). Influence of age and health behaviors on stroke risk: lessons from longitudinal studies. *Journal of the American Geriatrics Society, 58*, 325-328. doi:10.1111/j.1532-5415.2010.02915.x

Kraan, C., Stolwyk, R. J., & Testa, R. (2013): The Abilities Associated With Verbal Fluency Performance in a Young, Healthy Population Are Multifactorial and Differ Across Fluency Variants, *Applied Neuropsychology: Adult*, *20*, 159-168. doi:10.1080/09084282.2012.670157

For Peer Review

Laws, K. R., Duncan, A., & Gale, T. M. (2010). 'Normal' semantic-phonemic Fluency discrepancy in Alzheimer's disease? A meta-analytic study. *Cortex, 46*, 595–601. doi:10.1016/j.cortex.2009.04.009

Lezak M. D., Howieson D. B., Bigler E. D., & Tranel D. (2012). *Neuropsychological Assessment* (5th ed). New York, NY: Oxford University Press.

Lobo, A., Saz, P., Marcos, G., Día, J. L., de la Cámara, C., Ventura, T., … Aznar, S. (1995). Revalidation and standardization of the cognition mini-exam (first Spanish version of the Mini-Mental Status Examination) in the general geriatric population. *Medicina Clínica*, *112*, 767-774.

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

Luo, L., Luk, G., & Bialystok, E. (2010). Effects of language proficiency and executive control on verbal fluency performance in bilinguals. *Cognition, 114*, 29–41. doi:10.1016/j.cognition.2009.08.014.

Machado, T. H., Charchat, H., C., Santos, E. L., Amaral, V., Paes, P., Koenig, A.M., … Caramelli, P. (2009). Normative data for healthy elderly on the phonemic verbal fluency task – FAS. *Dementia & Neuropsychologia, 3*, 55–60. doi:10.1590/s1980-57642009dn30100011

Magaud, E., Kebir, O., Gut, A., Willard, D., Chauchot, F., Olie, J. P., … Krebs, M. O. (2010). Altered semantic but not phonological verbal fluency in young help-seeking individuals with ultra high risk of psychosis. *Schizophrenia research, 123*, 53–58. doi:10.1016/j.schres.2010.05.005

Marino, J. C., & Alderete, A. M. (2010). Valores normativos de pruebas de fluidez verbal categoriales, fonológicas, gramaticales y combinadas y análisis

For Peer Review

comparativo de la capacidad de iniciación. *Revista Neuropsicología, Neuropsiquiatría y Neurociencias, 10*, 82-93.

Martínez de la Iglesia, J., Onís Vilches, Mª C., Dueñas Herrero, R., Albert Colomer, C., Aguado Taberné, C., & Luque Luque, R. (2002). The Spanish version of the Yesavage abbreviated questionnaire (GDS) to screen depressive dysfunctions in patients older than 65 years. *Revista de Medicina Familiar y Comunitaria, 12*, 620-630. Retrieved from https://scielo.isciii.es/scielo.php?pid=S1131-57682002001000003&script=sci_abstract&tlng=en

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

Olabarrieta-Landa, L., Rivera, D., Galarza-Del-Angel, J., Garza, M. T., Saracho, C. P., Rodríguez, W., … Arango-Lasprilla, J. C. (2015). Verbal fluency tests: Normative data for the Latin American Spanish speaking adult population. *NeuroRehabilitation, 37*, 515–561. doi:10.3233/NRE-151279

Ostrosky-Solis, F., Gutierrez, A. L., Flores, M. R., & Ardila, A. (2007). Same or different? Semantic verbal fluency across Spanish-speakers from different countries. *Archives of Clinical Neuropsychology, 22*, 367–377. doi:10.1016/j.acn.2007.01.011

Peña-Casanova, J., Quiñones-Úbeda, S., Gramunt-Fombuena, N., Quintana-Aparicio, M., Aguilar, M., Badenes, D., … NEURONORMA Study Team. (2009). Spanish multicenter normative studies (NEURONORMA project): norms for verbal fluency test. *Archives of Clinical Neuropsychology, 24*, 395-411. doi:10.1093/arclin/acp042

For Peer Review

Pontón, M. O., Satz, P., Herrera, L., Ortiz, F., Urrutia, C. P., Young, R., … Namerow, N. (1996). Normative data stratified by age and education for the neuropsychological screening battery for Hispanics (NeSBHIS): Initial report. *Journal of the International Neuropsychological Society, 2*, 96–104. doi:10.1017/S1355617700000941

Quinn, C., Elman, L., McCluskey, L., Hoskins, K., Karam, C., & Woo, J. H. (2012). Frontal lobe abnormalities on MRS correlate with poor letter fluency in ALS. *Neurology, 79,* 583–588. doi:10.1212/WNL.0b013e3182635720

Raucher-Chéné, D., Achim, A. M., Kaladjian, A., & Besche-Richard, C. (2017). Verbal Fluency in Bipolar Disorders: A Systematic Review and Meta-Analysis. *Journal of affective disorders, 1,* 207, 359-366. doi:10.1016/j.jad.2016.09.039.

Rosselli, M., Ardila, A., Salvatierra, J., Marquez, M., Matos, L., & Weekes, V. A. (2002). A cross-linguistic comparison of verbal fluency tests. *International Journal of Neuroscience, 112(6)*, 759–776. doi:10.1080/00207450290025752

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

Saxton, J., Lopez, O. L., Ratcliff, G., Dulberg, C., Fried, L. P., Carlson, M. C., … Kuller, L. (2004). Preclinical Alzheimer disease: Neuropsychological test performance 1.5 to 8 years prior to onset. *Neurology, 63*, 2341–2347. doi:10.1212/01.wnl.0000147470.58328.50

Schmid, N. S., Taylor, K. I., Foldi, N. S., Berres, M., & Monsch, A. U. (2013). Neuropsychological signs of Alzheimer's disease 8 years prior to diagnosis. *Journal of Alzheimer's Disease, 34*, 537–546. doi:10.3233/JAD-121234

For Peer Review

Shao, Z., Janse, E., Visser, K., & Meyer, A. S. (2014). What do verbal fluency tasks measure? Predictors of verbal fluency performance in older adults. *Frontiers in Psychology, 22,* 5, 772. doi:10.3389/fpsyg.2014.00772.

Sheikh, J. L., & Yesavage, J. A. (1986). Geriatric Depression Scale (GDS). Recent evidence and development of a shorter version. *Clinical Gerontologist*, 5(1-2), 165-172. doi:10.1300/J018v05n01_09

Steenhuis, R. E., & Ostbye, T. (1995). Neuropsychological test performance of specific diagnostic groups in the Canadian Study of Health and Aging (CSHA). *Journal of Clinical and Experimental Neuropsychology, 17*, 773–785. doi:10.1080/01688639508405166

Stern, Y. (2009). Cognitive reserve. *Neuropsychologia, 47*, 2015-2028. doi:10.1016/j.neuropsychologia.2009.03.004

Stolwyk, R., Bannirchelvam, B., Kraan, C., & Simpson, K (2015). The Cognitive Abilities Associated With Verbal Fluency Task Performance Differ Across Fluency Variants and Age Groups in Healthy Young and Old Adults. *Journal of Clinical and Experimental Neuropsychology 37*, 70-83. doi:10.1080/13803395.2014.988125

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

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

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.

For Peer Review

*Archives of Clinical Neuropsychology, 14*, 167–177. doi:10.1093/arclin/14.2.167

Troyer, A. K., Moscovitch, M., Winocur, G., Leach, L., & Freedman, M. (1998). Clustering and switching on verbal fluency tests in Alzheimer's and Parkinson's disease. *Journal of International Neuropsychological Society, 4*, 137–143. doi:10.1017/s1355617798001374

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*, 80-89. doi:10.1017/s1355617706060115

Vaughan, R. M., Coen, R. F., Kenny, R. A., & Lawlor, B. A. (2018). Semantic and Phonemic Verbal Fluency Discrepancy in Mild Cognitive Impairment: Potential Predictor of Progression to Alzheimer's Disease. *Journal of the American Geriatrics Society*, *66*, 755-759. doi:10.1111/jgs.15294

Villodre, R., Sanchez-Alfonso, A., Brines, L., Nuñez, A. B., Chirivella, J., Ferri, J., & Noé, E. (2006). Verbal fluency tasks in a Spanish sample of young adults (20– 49 years of age): Normative data of clustering and switching strategies. *Neurología, 21*, 124–130.

Wyman-Chick, K. A. (2016). Verbal fluency in Parkinson's patients with and without bilateral deep brain stimulation of the subthalamic nucleus: a meta-analysis. *Journal of the International Neuropsychological Society, 22,* 478-485. doi:10.1017/S1355617716000035

Zimmermann, N., Parente, M. A. M. P., Joanette, Y., & Fonseca, R. P. (2014). Unconstrained, Phonemic and Semantic Verbal Fluency: Age and Education

For Peer Review

Effects, Norms and Discrepancies. *Psicologia Reflexã o Crítica, 27*, 1-9.

doi:10.1590/S0102-79722014000100007

For Peer Review

**Table 1.**

*Statistical properties of demographic and VF scores.*

| Gender | | | Male | Female |
|---|---|---|---|---|
| N | 257 | | 90 | 167 |
| | Mean (SD) | Min- Max | Mean (SD) | Mean (SD) |
| Education in years | 13.1 (3.8) | 3-20 | 13.9 (3.7) | 12.7 (3.7) |
| Age | 46.7 (25.3) | 17-100 | 48.1 (21) | 45.9 (27.4) |
| F | 12.3 (4.6) | 2-29 | 12.4 (4.5) | 12.2 (4.6) |
| A | 12.6 (4.8) | 2-30 | 13 (4.9) | 12.4 (4.8) |
| S | 13.8 (4.6) | 2-27 | 14.1 (4.3) | 13.6 (4.8) |
| Animals | 19.6 (6.8) | 5-42 | 21 (6.6) | 18.8 (6.8) |
| Fruits/vegetables | 16.8 (5) | 4-30 | 16.8 (4.5) | 16.8 (5.3) |
| Proper names | 22.8 (7.3) | 8-50 | 22.5 (6.1) | 23 (7.9) |
| Phonological FV | 38.6 (12.7) | 8-79 | 39.4 (12.3) | 38.2 (13) |
| Semantic VF | 59.3 (17.3) | 19-102 | 60.3 (15.1) | 58.7 (18.3) |

*Note:* Phonological FV: sum of number of words beginning with F, A, and S; Semantic VF: sum of number of animals, fruits/vegetables, and proper names.

For Peer Review

**Table 2.** *Correlation matrix of demographic variables and VF scores.*

| | Edu | Age | F | A | S | Ani | Fru/Veg | PN | PVF | SVF |
|---|---|---|---|---|---|---|---|---|---|---|
| Edu | 1 | | | | | | | | | |
| Age | -.433** | 1 | | | | | | | | |
| F | .561** | -.302** | 1 | | | | | | | |
| A | .571** | -.364** | .741** | 1 | | | | | | |
| S | .573** | -.394** | .712** | .746** | 1 | | | | | |
| Ani | .644** | -.458** | .678** | .662** | .669** | 1 | | | | |
| Fru/Veg | .581** | -.325** | .549** | .552** | .55** | .663** | 1 | | | |
| PN | .594** | -.488** | .649** | .597** | .638** | .791** | .671** | 1 | | |
| PVF | .627** | -.390** | .899** | .917** | .903** | .738** | .607** | .692** | 1 | |
| SVF | .674** | -.482** | .701** | .674** | .694** | .922** | .836** | .93** | .76** | 1 |

*Note:* Edu: education in years; F: total number of words beginning with F; A: total number of words beginning with A; S: total number of words beginning with S; Ani: total number of animals; Fru/veg: total number of fruits and vegetables: PN: total number of proper names. PVF: Phonological Verbal Fluency (sum of number of words beginning with F, A, and S); SVF: Semantic Verbal Fluency (sum of number of animals, fruits/vegetables, and proper names).
** p<.01

For Peer Review

**Table 3.**
*Results from multiple regression analyses using VF scores as criterion and education and age as predictors.*

| | B | SE(B) | $\beta$ | $t$ | $p$ | Partial |
|---|---|---|---|---|---|---|
| **F** | | | | | | |
| Age | -.013 | .01 | -.072 | -1.254 | .211 | -.078 |
| Education | .642 | .07 | .529 | 9.213 | .000 | .5 |
| **A** | | | | | | |
| Age | -.027 | .011 | -.144 | -2.551 | .011 | -.158 |
| Education | .651 | .072 | .508 | 9.002 | .000 | .492 |
| **S** | | | | | | |
| Age | -.033 | .01 | -.179 | -3.21 | .001 | -.197 |
| Education | .613 | .069 | .496 | 8.864 | .000 | .486 |
| **Animals** | | | | | | |
| Age | -.059 | .014 | -.22 | -4.284 | .000 | -.26 |
| Education | .991 | .093 | .549 | 10.664 | .000 | .556 |
| **Fruits/vegetables** | | | | | | |
| Age | -.018 | .011 | -.091 | -1.605 | .11 | -.1 |
| Education | .72 | .075 | .541 | 9.598 | .000 | .516 |
| **Proper names** | | | | | | |
| Age | -.082 | .015 | -.284 | -5.339 | .000 | .318 |
| Education | .918 | .103 | .471 | 8.874 | .000 | .486 |
| **Phonological VF** | | | | | | |
| Age | -.073 | .027 | -.146 | -2.73 | .007 | -.169 |
| Education | 1.906 | .181 | .563 | 10.538 | .001 | .552 |
| **Semantic VF** | | | | | | |
| Age | -.159 | .034 | -.233 | -4.733 | .000 | -.285 |
| Education | 2.629 | .226 | .573 | 11.619 | .000 | .589 |

*Note:* Education: education in years; F: total number of words beginning with F; A: total number of words beginning with A; S: total number of words beginning with S; PVF: Phonological Verbal Fluency (sum of number of words beginning with F, A, and S); SVF:

For Peer Review

Semantic Verbal Fluency (sum of number of animals, fruits/vegetables, and proper names); Semipart: semipartial.

For Peer Review

**Table 4.**
*Statistical properties of the demographic and VF variables for each education and age level group.*

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| Education: <13 years; Age: <60 years (N=81; Male: 22) | | | | |
| F | 11.5 | 2.9 | 5 | 18 |
| A | 12.1 | 2.8 | 5 | 18 |
| S | 13.9 | 2.9 | 7 | 21 |
| Ani | 18.7 | 3.4 | 12 | 26 |
| Fru/Veg | 16 | 3.4 | 10 | 24 |
| PN | 22.5 | 4.2 | 12 | 37 |
| PVF | 37.6 | 6.7 | 23 | 52 |
| SVF | 57.3 | 8.9 | 36 | 83 |
| Education: <13 years; Age: >=60 years (N=61; Male: 13) | | | | |
| F | 8.4 | 3.7 | 2 | 20 |
| A | 8.1 | 3.8 | 2 | 19 |
| S | 9.1 | 4.1 | 2 | 20 |
| Ani | 12 | 4.5 | 5 | 26 |
| Fru/Veg | 12.2 | 4.4 | 4 | 27 |
| PN | 15.1 | 5.3 | 8 | 31 |
| PVF | 25.6 | 10.2 | 8 | 59 |
| SVF | 39.2 | 12.3 | 19 | 70 |
| Education: >=13 years; (N=115; Male: 55) | | | | |
| F | 14.9 | 4.3 | 4 | 29 |
| A | 15.3 | 4.6 | 5 | 30 |
| S | 16.1 | 4.1 | 7 | 27 |
| Ani | 24.3 | 5.6 | 13 | 42 |
| Fru/Veg | 19.9 | 4 | 10 | 30 |
| PN | 27.1 | 6.5 | 14 | 50 |
| PVF | 46.3 | 11.2 | 18 | 79 |
| SVF | 71.3 | 13.1 | 44 | 102 |

*Note:* Edu: education in years; F: total number of words beginning with F; A: total number of words beginning with A; S: total number of words beginning with S; Ani: total number of animals; Fru/veg: total number of fruits and vegetables: PN: total number of proper names; PVF: Phonological Verbal Fluency (sum of number of words beginning with F, A, and S); SVF: Semantic Verbal Fluency (sum of number of animals, fruits/vegetables, and proper names).

For Peer Review

**Table 5.**

*Percentile ranks for F, A, S, and total Phonological VF stratified by education and age (for the low education level group).*

| Percentile | F | | A | | S | | Total PVF | |
|---|---|---|---|---|---|---|---|---|
| | <60* | 60+* | <60* | 60+* | <60* | 60+* | <60* | 60+* |
| Education: <13 years | | | | | | | | |
| 5 | 7 | 3 | 7.1 | 2.1 | 9.1 | 4 | 26.3 | 12 |
| 10 | 8 | 3 | 8 | 3.2 | 11 | 4 | 29.2 | 13 |
| 15 | 9 | 4.3 | 10 | 4 | 11 | 5 | 31 | 14 |
| 20 | 9 | 5 | 10 | 5 | 11.4 | 5.4 | 32.4 | 17 |
| 25 | 9 | 6 | 10 | 5 | 12 | 6 | 33 | 17.5 |
| 30 | 10 | 6 | 11 | 6 | 12 | 6.6 | 33 | 19 |
| 35 | 10.7 | 7 | 11 | 6 | 13 | 7 | 34 | 20 |
| 40 | 11 | 7 | 11 | 7 | 13 | 7 | 35 | 21.8 |
| 45 | 11 | 7 | 12 | 7 | 13 | 8 | 36 | 22.9 |
| 50 | 11 | 7 | 12 | 8 | 14 | 8 | 37 | 23 |
| 55 | 12 | 8.1 | 12 | 9 | 14 | 9 | 38 | 27.1 |
| 60 | 12 | 10 | 13 | 9 | 14 | 10 | 38 | 28.2 |
| 65 | 12.3 | 10 | 13 | 9 | 15 | 10 | 39 | 29.3 |
| 70 | 13 | 10.4 | 13.4 | 10 | 15 | 10.4 | 40.4 | 30 |
| 75 | 13 | 11 | 14 | 10.5 | 16 | 11 | 42 | 31.5 |
| 80 | 14 | 11.6 | 15 | 11 | 16 | 12.6 | 43.6 | 32.6 |
| 85 | 15 | 13 | 15 | 11.7 | 17 | 13 | 46.7 | 36.7 |
| 90 | 16 | 13 | 15.8 | 13 | 18 | 15.6 | 48 | 39.8 |
| 95 | 17 | 14.9 | 17.9 | 15.9 | 19 | 17 | 49.9 | 44.7 |

| Percentile | F | A | S | Total PVF |
|---|---|---|---|---|
| Education: >=13 years | | | | |
| 5 | 7.8 | 8 | 9 | 28.8 |
| 10 | 9 | 9 | 12 | 31 |
| 15 | 10.4 | 10 | 12 | 34.4 |
| 20 | 11 | 11 | 12.2 | 37 |
| 25 | 12 | 12 | 13 | 38 |
| 30 | 12.8 | 12.8 | 14 | 39.8 |
| 35 | 13 | 14 | 14.6 | 41.6 |
| 40 | 14 | 14 | 15 | 43 |
| 45 | 14 | 15 | 15.2 | 45 |
| 50 | 15 | 15 | 16 | 46 |
| 55 | 15 | 17 | 16 | 47 |
| 60 | 16 | 17 | 17 | 49 |
| 65 | 17 | 17 | 17.4 | 51 |

For Peer Review

| | | | | |
|---|---|---|---|---|
| 70 | 17 | 18 | 18 | 53.2 |
| 75 | 18 | 18 | 19 | 55 |
| 80 | 19 | 19 | 19 | 56 |
| 85 | 19 | 20 | 20 | 57 |
| 90 | 20 | 21 | 21.4 | 59.8 |
| 95 | 22 | 23 | 24 | 66 |

*Note*: * Age in years; F: total number of words beginning with F; A: total number of words beginning with A; S: total number of words beginning with S; PVF: Phonological Verbal Fluency (sum of number of words beginning with F, A, and S).

For Peer Review

**Table 6.**

*Percentile ranks for Animals, Fruits/Vegetables, Proper Names, and total Semantic VF stratified by education and age (for the low education level group).*

| Percentile | Animals | | Fru/Veg | | Proper names | | Total SVF | |
|---|---|---|---|---|---|---|---|---|
| | <60* | 60+* | <60* | 60+* | <60* | 60+* | <60* | 60+* |
| Education: <13 years | | | | | | | | |
| 5 | 14 | 6 | 11 | 6 | 17 | 9 | 44.1 | 12 |
| 10 | 14.2 | 6.2 | 11.2 | 7 | 18.2 | 9 | 47.2 | 13 |
| 15 | 16 | 7 | 12.3 | 7.3 | 19 | 9.3 | 49 | 14 |
| 20 | 16 | 8 | 13 | 8.4 | 19 | 10 | 50 | 17 |
| 25 | 16 | 9 | 13.5 | 9 | 20 | 11 | 50.5 | 17.5 |
| 30 | 16.6 | 9 | 14 | 10 | 20 | 12 | 52 | 19 |
| 35 | 17 | 10 | 14 | 10 | 20 | 12 | 53 | 20 |
| 40 | 17 | 10 | 15 | 10.8 | 21 | 12.8 | 54 | 21.8 |
| 45 | 17.9 | 10.9 | 15 | 11 | 22 | 13 | 55 | 22.9 |
| 50 | 18 | 11 | 16 | 12 | 22 | 14 | 56 | 23 |
| 55 | 18 | 12.1 | 16 | 13 | 23 | 15 | 57.1 | 27.1 |
| 60 | 19 | 13 | 17 | 13 | 23 | 16 | 59.2 | 28.2 |
| 65 | 20 | 14 | 17 | 13 | 24 | 16 | 60 | 29.3 |
| 70 | 21 | 14 | 18 | 14 | 24 | 17.4 | 61 | 30 |
| 75 | 21 | 14.5 | 18 | 14 | 25 | 18.5 | 62.5 | 31.5 |
| 80 | 22 | 15.6 | 20 | 14.6 | 26 | 20 | 64.6 | 32.6 |
| 85 | 23 | 16 | 20 | 16.7 | 27 | 20 | 65.7 | 36.7 |
| 90 | 24.8 | 18 | 21 | 18.8 | 27.8 | 22 | 69.6 | 39.8 |
| 95 | 25 | 20.9 | 21.9 | 20 | 29 | 26.8 | 73 | 44.7 |

| Percentile | Animals | Fru/Veg | Proper names | Total SVF |
|---|---|---|---|---|
| Education: >=13 years | | | | |
| 5 | 15.8 | 14 | 16.8 | 47 |
| 10 | 17 | 15 | 18.6 | 53.2 |
| 15 | 18 | 16 | 21 | 56.8 |
| 20 | 19 | 16 | 21.2 | 60 |
| 25 | 20 | 17 | 23 | 63 |
| 30 | 21 | 17 | 24 | 66 |
| 35 | 22 | 18 | 24 | 68 |
| 40 | 23 | 18 | 25 | 69 |
| 45 | 23 | 19 | 26 | 70 |
| 50 | 24 | 20 | 27 | 71 |
| 55 | 25 | 20 | 27 | 71 |
| 60 | 25.6 | 21 | 29 | 73 |
| 65 | 26 | 22 | 29.4 | 74 |

For Peer Review

| | | | | |
|---|---|---|---|---|
| 70 | 27.2 | 22 | 30 | 76 |
| 75 | 28 | 23 | 31 | 80 |
| 80 | 29 | 24 | 33 | 84 |
| 85 | 30 | 24 | 33 | 86.2 |
| 90 | 32 | 25 | 35.4 | 89 |
| 95 | 34.2 | 27 | 39.4 | 95.2 |

*Note*: * Age in years; Animals: total number of animals; Fru/veg: total number of fruits and vegetables: PN: total number of proper names; SVF: Semantic Verbal Fluency (sum of number of animals, fruits/vegetables, and proper names).

For Peer Review

STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** p.1 | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found |
| **Introduction** | | |
| Background/rationale pp. 2-5 | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives p. 5 | 3 | State specific objectives, including any prespecified hypotheses |
| **Methods** | | |
| Study design pp. 5-6 | 4 | Present key elements of study design early in the paper |
| Setting pp.5-6 | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants pp. 5-6 | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables pp. 5-6 | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement pp. 5-6 | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group |
| Bias | 9 | Describe any efforts to address potential sources of bias |
| Study size | 10 | Explain how the study size was arrived at |
| Quantitative variables p. 7 | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods p. 7 | 12 | (*a*) Describe all statistical methods, including those used to control for confounding |
| | | (*b*) Describe any methods used to examine subgroups and interactions |
| | | (*c*) Explain how missing data were addressed |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses |

Continued on next page



For Peer Review

| | | |
|---|---|---|
| **Results** | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| | | (b) Give reasons for non-participation at each stage |
| | | (c) Consider use of a flow diagram |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| | | (b) Indicate number of participants with missing data for each variable of interest |
| pp. 7-8 | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| pp.7-8 | | *Cross-sectional study*—Report numbers of outcome events or summary measures |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included |
| pp. 8-9 | | (*b*) Report category boundaries when continuous variables were categorized |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| **Discussion** | | |
| Key results | 18 | Summarise key results with reference to study objectives |
| pp. 10-13 | | |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| pp. 13-14 | | |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| pp. 10-13 | | |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results |
| pp. 12-13 | | |
| **Other information** | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |
| p. 14 | | |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

For Peer Review