Effect of Aging, Education, Reading and Writing, Semantic Processing and Depression Symptoms on Verbal Fluency

Efeito da Idade, Escolaridade, Hábitos de Leitura e Escrita, Processamento Semântico e Sintomas de Depressão na Fluência Verbal

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Abstract

Verbal fluency tasks are widely used in (clinical) neuropsychology to evaluate components of executive functioning and lexical-semantic processing (linguistic and semantic memory). Performance in those tasks may be affected by several variables, such as age, education and diseases. This study investigated whether aging, education, reading and writing frequency, performance in semantic judgment tasks and depression symptoms predict the performance in unconstrained, phonemic and semantic fluency tasks. This study sample comprised 260 healthy adults aged 19 to 75 years old. The Pearson correlation coefficient and multiple regression models were used for data analysis. The variables under analysis were associated in different ways and had different levels of contribution according to the type of verbal fluency task. Education had the greatest effect on verbal fluency tasks. There was a greater effect of age on semantic fluency than on phonemic tasks. The semantic judgment tasks predicted the verbal fluency performance alone or in combination with other variables. These findings corroborate the importance of education in cognition supporting the hypothesis of a cognitive reserve and confirming the contribution of lexical-semantic processing to verbal fluency.
Keywords: Verbal fluency, age, education, reading and writing habits, depression, semantic judgment.

Resumo

As tarefas de fluência verbal são amplamente empregadas na clínica neuropsicológica para avaliar os componentes de funções executivas e processamento léxico-semântico (linguagem e memória semântica). O desempenho nessas tarefas pode ser influenciado por diferentes variáveis, como idade, escolaridade e diferentes patologias. Este estudo investigou se a idade, escolaridade, frequência dos hábitos de leitura e escrita, o desempenho em tarefas de julgamento semântico e sintomas de depressão predizem os desempenhos em tarefas de fluência verbal de critério livre, fonêmico-ortográfico e semântico. Participaram desse estudo 260 adultos saudáveis entre 19 e 75 anos. Foi utilizada a correlação de Pearson e da análise de regressão múltipla. As variáveis analisadas foram associadas em diferentes modelos combinatórios e apresentaram distintos níveis de explicação de acordo com o tipo de fluência verbal. A escolaridade foi a variáveis que melhor contribuiu para a explicação do desempenho nas tarefas de fluência verbal, seguida pela idade, principalmente na tarefa fonêmico-ortográfica. O desempenho nas tarefas de julgamento semântico predisse a *performance* da fluência verbal isoladamente ou em combinação com as demais variáveis. Esses resultados corroboram a importância da escolaridade na cognição, sustentando a hipótese da reserva cognitiva e confirmam a implicação do processamento léxico-semântico na fluência verbal.
Palavras-chave: Fluência verbal, idade, escolaridade, leitura e escrita, depressão, julgamento semântico.

A fundamental aspect of neuropsychological diagnoses is the complex effect of genetic, demographic, clinical and cultural variables on the dynamic aspects of cognition, which are measured using tasks such as verbal fluency (VFT). Performance in tasks that involve the production of words may be affected, in different ways, by several

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biological, social and cultural factors, such as age, education (Khalil, 2010; Peña-Casanova et al., 2009), ethnicity (Kempler, Teng, Dick, Taussig, & Davis, 1998), socioeconomic status and rural or urban origin (Grupta et al., 2011). The cooperative interaction of different components of cognitive processes in performing VFT should also be considered, according to the criterion used. Different evidences support the performance in phonemic and semantic VFTs involves correlation among declarative memory and vocabulary (Federmeier, Mclennan, Ochoa, & Kutas, 2002), information processing speed (Ruff, Light, Parker, & Levin, 1997), attention processes (Mirman, McClelland, Holt, & Magnuson, 2008) and language (Rodrigues, Yamashita, & Chiappetta, 2008).

Tasks that involve multiple cognitive resources for their performance are often used in clinical neuropsychology. This is the case of VFTs, a paradigm largely used to evaluate the integrity of executive functions in association with the frontal cortex functioning (Azuma, 2004; Benton, 1984; Spreen & Strauss, 1991; Tröster et al., 1998). VFTs have also been used to investigate the capacity of an individual to explore the lexical-semantic memory and to evaluate the strategies used for that purpose. However, little attention has been given to the lexical-semantic processing required in these tasks, which demand the free production of words or their generation according to specific restrictive criteria during a short period of time (Fonseca, Fachel, Chaves, Liedtke, & Parente, 2007).

The first VFT version was developed by Spreen and Benton (1969) using the FAS fluency task, in which the participant was asked to produce words that begin with one of the letters in the test name (Brucki & Rocha, 2004). This same test is known as the Controlled Oral Word Association Test (COWAT; Steiner, Mansur, Brucki, & Nitrini, 2008), and, early on, its results in clinical contexts were used as factors of general cognitive functioning. After the spread of the FAS paradigm, other tests have been developed and studied to assess their efficacy in discriminating clinical conditions. The variation of rules (criteria) for word production and the time used to perform the task define the different VFT paradigms.

The most frequent tasks adopt phonemic and semantic criteria and unconstrained word production. Phonemic criterion defines the production of words according to the selection of a letter or phoneme unit. The semantic VFT, developed by McCarthy (1972) according to studies about the neuropsychological performance of adults with brain disorders conducted by Milner in 1964 (Welsh, Pennington, & Groisser, 1991), assesses the production of words by children and illiterate individuals. In this task, participants are asked to produce words in a category defined by the establishment of a theme association, such as *animals* (Brucki & Rocha, 2004; Elst, Boxtel, Breukelen, & Jolles, 2006) and *clothing* (Fonseca, Parente, Cote, Ska, & Joanette, 2008). For that criterion, semantic memory is explored first according to conceptual knowledge, after which strategies for a specific semantic category are used

(Szatkowska, Grabowska, & Szymanska, 2000). The unconstrained criterion defines the spontaneous production (free production) of any word and the maximal cognitive production in phonemic tasks (Beausoleil, Fortin, Le Blanc, & Joanette, 2003). This criterion may be more sensitive in detecting cognitive variations due to lesions to the right or left brain hemisphere, as well as changes observed during healthy ageing. Moreover, performance in free VFTs may provide more information for qualitative analyses (Le Blanc & Joanette, 1996). In Brazil, most studies with VFT use semantic and phonemic criteria, followed by unconstrained tasks. Internationally, these three criteria are used in test batteries and protocols that investigate neuropsychological profiles and the integrity of communication processes (Joanette, Côté, & Ska, 2004).

The discriminating capacity of VFT has been repeatedly confirmed in clinical neuropsychology, both for neurological and neuropsychiatric disorders. Variations in VFT scores, as well as specific error patterns, have been associated with the different stages of progression of some types of dementia (Monsch, Butters, Salmon, & Katzman, 1992) and several mental diseases (Brucki & Rocha, 2004).

The discrepancies in VFT performance have been associated with several pathological conditions, such as Alzheimer's disease (Arnaíz & Almkvist, 2003), schizophrenia (Allen, Liddle, & Frith, 1993; Beilen et al., 2004), Parkinson's disease (Monetta & Pell, 2006), depression (Videbech et al., 2003), head trauma (Curtis, Thompson, Greve, & Bianchini, 2007; Raskin & Rearick, 1996) and amyotrophic lateral sclerosis (Abrahams et al., 2000). VFTs have also been used for the differential diagnosis of Alzheimer's and semantic and ischemic vascular dementia (Elst et al., 2006; Tierney, Blach, & Szalai, 2001), right and left temporal lobe epilepsy (N'Kaoua, Lespinet, Barsse, & Clavierie, 2001) and types of dementia and depression in the elderly (Cipolotti & Maguire, 2003).

Studies conducted in Brazil suggest that the use of a semantic criterion might be more sensitive to discriminating the initial phases of neurodegenerative and psychopathological disorders (Brucki & Rocha, 2004; Brucki, Rocha, & Lima, 2002). However, results of studies conducted in the United States suggest that poor performances in phonemic tasks provide the best evidence to diagnose these disorders (Allen et al., 1993; Gurd, Ward, & Hodges, 1990; Solomon et al., 1998). In addition, VFTs with letter or phoneme rules seem to address the associations with frontal lobe functioning, particularly in the left hemisphere of healthy middle-aged adults (Herrmann, Ehlis, & Fallgatter, 2003). That criterion leads to the activation of the dorsolateral prefrontal cortex and the left inferior cingulated gyrus, as well as the right cerebellum and the right orbitofrontal cortex (Schlosser et al., 1998). Studies have also reported on greater activation of the left hemisphere for VFTs that use a lexical criterion (Herrmann et al., 2003; N'Kaoua et al., 2001).

In contrast, semantic criterion seems to be more closely associated with areas of the right brain hemisphere, par-

ticularly the ventromedial frontal area and the cingulated gyrus (Thompson-Schill, Farah, Desposito, & Aguirre, 1997). However, some studies suggest that brain activation is bilateral for tasks that use a semantic criterion (Dickins et al., 2001). Semantic tasks are impaired in patients with lesions in both hemispheres, which suggests that the semantic process for lexical generation depends on the collaboration of both hemispheres (Borovsky, Saygin, Bates, & Dronkers, 2007).

In general, the difficulty in establishing performance parameters for these tasks results from the effect of specific variables on word production. Current neuropsychological literature has increasingly discussed the effect of several variables on verbal fluency performance, such as age, education and life experiences (Bozikas, Kosmidis, & Karavatos, 2004; Harrison, Buxton, Hussain, & Wise, 2000; Salthouse & Davis, 2006). Education has been found to affect the use of restrictive semantic VFTs when analyzed at total task time and at its different time intervals (Brucki, Malheiros, Okamoto, & Bortolucci, 2004; Brucki & Rocha, 2004). Cluster analysis of the results of semantic tasks showed that the individuals with a higher degree of education, with or without brain lesions, were in the high performance cluster (Beausoleil et al., 2003). This effect was also found in verbal fluency studies that used an initial-letter VFT (Ratcliff et al., 1998) for fluent English speakers.

The effect of age has been defined according to the time spent to perform the task, because information processing slows down in old age (Rodrigues et al., 2008; Rönnlund, Nybertg, Backman, & Nilsson, 2005; Salthouse, 1996). Another factor may be associated with the negative effect of age on lexical retrieval (Mansur, Radanovic, Rüegg, Mendonça, & Scaff, 2002; Obler, Au, & Albert, 1995; Taylor & Burke, 2002) and on inhibitory functions (Bryan & Luszcz, 2000). However, age and education may act alone or in different forms of interaction, which suggests the existence of a complex effect between these variables, which may depend on the cognitive domain under study (Ardilla, Ostrosky-Solis, Rosselli, & Gomez, 2000). Studies using VFTs showed that education may play a role on the effect of age: (a) older people with a high educational level had a better performance when different task criteria were adopted than older people with an intermediate or low educational level (Henry & Phillips, 2006); (b) adults produced more words than older individuals only in the groups with up to four years of schooling (Rodrigues et al., 2008); and (c) people about 70 years old and a high educational level had a performance that was similar to young people about 20 years old with a low educational level (Federmeier et al., 2002). The authors of the latter study believed that more education may compensate for the decline of verbal fluency due to aging, probably due to the higher number of linguistic experiences (such as reading and writing) along life. This evidence seems to suggest that life habits, associated with a history of cognitive stimula-

tion, may mitigate the decline of some cognitive domains during aging. Such findings may support the cognitive reserve hypothesis (Mortimer, Snowdow, & Markesbery, 2003; Stern, 2009).

However, not many studies have been conducted to investigate the concurrent contribution of sociocultural, biological and cognitive factors to the performance of a task so often used clinically, such as the verbal fluency tests. These factors seem to contribute distinctly to the different cognitive components demanded for each VFT modality. To investigate this association, this study analyzed the effect of age, education, reading and writing frequency, depression symptoms and scores of semantic judgment task on the performance of VFTs by healthy adults. Our main hypothesis was that education (in number of schooling years) and the performance in semantic judgment tasks would be the best predictors of performance in VFTs.

Method

This quantitative and correlational study, approved by the Ethics in Research Committee of the Psychology Institute, *Universidade Federal do Rio Grande do Sul* (UFR-GS), Porto Alegre, Brazil, originated from the study that validated the Montreal Communication Evaluation Tests (*Bateria Montreal de Avaliação da Comunicação - MAC Battery*) for use with speakers of Brazilian Portuguese (Fonseca et al., 2008).

Participants

This study enrolled 260 adults (198 women) aged 19 to 75 years (M=46.68, SD = 17.14) who had 2 to 25 years of formal education (M=9.73; SD = 6.04). Participants had a low (2 to 4 years of schooling; n=87), intermediate (5 to 8 years; n=59) or high (9 years of more; n=114) educational level. Of all participants, 94 were 19 to 39 years old; 83, 40 to 59; and 83, 50 to 75.

Instruments and Procedures

After signing an informed consent term, participants responded the instruments for sample selection. (a) Sociodemographic and Health Aspects Questionnaire: which collected personal data, such as age, education, income, medical history and health aspects. Education was defined in number of years in elementary and secondary school, higher education and post graduation, but did not include the years when a grade was repeated. (b) Scale of reading and writing frequency: a self-report scale that was part of the sociodemographic and general health questionnaire. Participants were classified according to how often they read (magazines, newspapers, books, other reading material) and wrote (texts, messages written on paper, other types of writing). Four points were assigned for daily reading and writing, 3 for some days in the week, 2 for once a week, and 1 for occasional reading and writing. Total score was the sum of eight partial scores. (c) A geriatric

depression scale (GDS-30; Yesavage, Brink, Rose, & Lurn, 1983) with 30 yes/no questions to screen for signs of depression in the elderly population, but which can also be used from adolescence on (Lezak, Howienson, & Loring, 2004). A score of 0 to 10 points was classified as absence of depression; from 11 to 22, as progressive depression; and above 23 points, as severe depression. (d) Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975, adapted for use with the local population by Chaves & Izquierdo, 1992): brief instrument to evaluate mental status, used internationally to investigate signs that may suggest dementia. The cut-off point for individuals with up to 4 years of education was 17, and for those with 5 or more years of schooling, 24 points.

In the study conducted by Fonseca et al. (2008), the participants in the study to validate the MAC Battery were included if they met the following criteria: (a) minimum age of 19 years; (b) minimum education of 2 years; (c) MMSE scores that did not suggest dementia; (d) GDS-30 scores that did not suggest depression; (e) no uncorrected visual or hearing impairment; (f) no complaints about memory. In addition, participants were excluded if they reported neurological problems or psychiatric disorders, had a current or previous history of abuse of alcohol, benzodiazepine, antipsychotic agents or any other drug, or had signs of general developmental disorders.

The verbal fluency and semantic judgment tests were applied as developed for the *Protocole Montréal d'Évaluation de la Communication – Protocole MEC* (Côté, Payer, Giroux, & Joanette, 2007; Joanette et al., 2004), adapted to Brazilian Portuguese (Fonseca, Parente, Côté, & Joanette, 2007; Fonseca et al., 2008). Three types of free VFTs were applied: (a) unconstrained verbal fluency: the individual had to say the greatest number possible of words during two minutes and 30 seconds; proper names or numbers were not allowed. (b) phonemic verbal fluency: the participant had to produce as many words as possible that began with the letter "p", except proper names, for two minutes. (c) semantic verbal fluency: the participant should produce the greatest number of words for clothes in two minutes. The semantic judgment task was composed of 24 pairs of stimulus-words, 12 of which belonged to the same semantic category. Stimuli (words) were presented both verbally and visually, and the person under evaluation was asked about the presence or not of a semantic connection between the two words. In case the answer was yes, the participant was asked to describe the semantic relationship.

The performance of individuals in the VFTs and semantic judgment tests were evaluated according to the score of right answers, as defined in the manual to apply and score of MAC Battery. For verbal fluency, one point was scored for each word produced correctly. Answers were incorrect if the words were not accepted in the test (for example, proper names, numbers, or answers that violated the restrictions established previously) or if the words were repeated or derivatives in the same grammatical class. Performance in semantic judgment task was scored according to the total number of right answers in identifying related words (identification score) and explaining the relations between words (explanation score).

Data Analysis

The dependent variables in this study were the total scores for participants in the VFTs and in the semantic judgment task. Age, education, reading and writing frequency and depression symptoms scores were continuous variables.

First, the correlations between all variables were analyzed using the Pearson correlation coefficient to identify significant correlations with performance in VFTs. After that, a Stepwise Multiple Regression analysis was used to identify the combination of variables with the best capacity to explain VFT performances. This method of analysis ranked the combined variables according to the one that, alone, had the highest coefficient of multiple determinations (R^2) to avoid the effect of multicolinearity. The final model was built according to the criterion with the greatest predictive effect for the combinations of two, three and, finally, four variables. This analysis was completed with the definition of an algorithmic equation for the final model, generated by the stepwise regression analysis for each of the VFT criteria.

Results

Correlation Analysis

Table 1 shows the correlation coefficients for the variables under study in the total sample. The Pearson correlation analysis revealed that the strongest correlation was between the performances in VFTs and education (in years), followed by the performance in semantic judgment, reading and writing frequency and, at last, age, as shown in Table 1.

Performance in VFT was moderately correlated with education, and with semantic judgment identification and explanation and education, whereas weak and negative correlations were found for age and VFT. Moderate correlations were also found between VFT correct answers and reading and writing frequency. There were no significant correlations between the scores that indicated depression and performance in VFT. The correlations between performances in VFT were high and positive.

Regression Analysis

The variables with significant correlations with VFT were included in the stepwise multiple regression model. The simple and adjusted coefficients, the Durbin-Watson statistics, and the colinearity coefficients were defined, as well as the level of significance of the variables in each model. The objective was to identify the model of variable combination with the greatest predictive power

Table 1

Correlations among VFT Performance, Age, Sociocultural Variables, Depression Indices and Semantic Judgment Performance

	1	2	3	4	5	6	7	8	9
1. Age	1								
2. Education	-.132**	1							
3. Depression	-.062	-.144**	1						
4. RWF	-.196*	.416*	-.141**	1					
5. SJT I.	-.073	.417*	-.043	.210*	1				
6. SJT E.	-.119	.565*	-.081	.254*	.767*	1			
7. VFT U	-.338*	.486*	-.043	.398*	.398*	.469*	1		
8. VFT P	-.268*	.516*	-.081	.414*	.391*	.504*	.636*	1	
9. VFT S	-.323*	.558*	.003	.395*	.394*	.513*	.630*	.618*	1

Note. Unconstrained verbal fluency task (VFT U); phonemic verbal fluency task (VFT P); semantic verbal fluency task (VFT S); reading and writings frequency (RWF); semantic judgment task – identification score (SJT I); semantic judgment task – explanation score (SJT E.).
$p \leq .001$*; $p \leq .05$**.

for VFT performances. For all the tasks criteria, the stepwise method excluded semantic judgment identification. This suggests that the possible interactions between age, education, reading and writing and semantic judgment explanation had a greater explanatory capacity for all the types of VFTs.

For the unconstrained VFT, the combination of four variables was adequate for the diagnostic criteria:

Durbin-Watson statistics was D=1.897, and there was no statistical colinearity, as the variance factors ranged from 1.240 to 1.856. In addition, when these variables were ranked, results confirmed that education had the best predictive value, as shown in Table 2 for the general sample. Table 3 shows the beta scores of the variables in this model.

Table 2

Results of the Multiple Regression Analysis for Unconstrained VFT and the Variables under Study

Variables	R	R^2	R^2a	F (ANOVA)	Standard Error	Durbin-Watson
Education	.486	.236	.233	79.71*	20.48	
Education, Age	.559	.312	.307	58.37*	19.46	
Education, Age Sem. Julg. Exp.	.601	.361	.354	48.23*	18.80	
Education, Age Sem. Julg. Exp. Reading Writ. Freq.	.624	.389	.380	40.62*	18.42	1.897

Note. The variables are distributed according to the ranking suggested by the stepwise model.
$p \leq .05$*; R^2a = adjust correlation coefficient.

Table 3
Coefficient of Multiple Determinations and Beta Scores of the Stepwise Regression Model for VFT

Variables	*B*	b	Standard Error
Education	.885*	.228	.244
Age	-.327*	-.240	.068
Sem. Julg. Exp.	2.149*	.262	.488
Reading Writ. Freq.	.832*	.187	.243
Intercept = 22.328		R^2 =.389	
		R^2a =.380	
		R =.624	

$p \leq .001$*; R^2a = adjust correlation coefficient.

These values estimate mean performance in unconstrained VFT of healthy individuals based on their performance in the semantic judgment explanation tasks and their reading and writing frequency. It also used data about age and years of formal education, expressed as education in years.

For phonemic verbal fluency, the combination of the four variables was adequate for the Durbin-Watson criteria (*D*=1.882) and the statistical colinearity (tolerance ranging from 1.046 to 1.656). When these variables were ranked, results confirmed that education had the best predictive value, as shown in Table 4. Table 5 shows the beta scores of the variables in this model.

Table 4
Results of the Stepwise Multiple Regression Analysis for Phonemic VFT and the Variables under Study

Variables	*R*	R^2	R^2a	*F* (ANOVA)	Standard Error	Durbin-Watson
Education	.516	.267	.264	93.83*	7.626	
Education Sem. Julg. Exp.	.577	.333	.328	64.12*	7.288	
Education Sem. Julg. Exp. Reading Writ. Freq.	.614	.377	.370	51.61*	7.057	
Education Sem. Julg. Exp. Reading Writ. Freq. Age	.634	.402	.392	42.81*	6.928	1.882

Note. The variables are distributed according to the ranking suggested by the stepwise model.
$p \leq .05$*; R^2a = adjust correlation coefficient.

Table 5
Coefficient of Multiple Determinations and Beta Scores of the Stepwise Regression Model for Phonemic VFT

Variables	*B*	b	Standard Error
Education	.361*	.245	.092
Sem. Julg. Exp.	.913*	.293	.184
Reading Writ. Freq.	.345*	.204	.091
Age	-.084*	-.161	.026
Intercept = 9.259		R^2 =.402	
		R^2a =.392	
		R =.634	

$p \leq .001$*; R^2a = adjust correlation coefficient.

The regression result for semantic VFT is show in Table 6. Durbin-Watson statistic for the combination of variables was *D*=2.011, and statistical colinearity with variable tolerance ranged from 1.564 to 1.982. Beta scores is presented in Table 7.

Table 6
Results of the Stepwise Multiple Regression Analysis for Semantic VFT and the Variables under Study

Variables	*R*	*R*²	*R*²a	*F* (ANOVA)	Standard Error	Durbin-Watson
Education	.558	.312	.309	116.88*	6.190	
Education Age	.612	.375	.370	77.01*	5.911	
Education Age Sem. Julg. Exp.	.653	.426	.419	63.34*	5.675	
Education Age Sem. Julg. Exp. Reading Writ. Freq.	.667	.444	.436	50.96*	5.595	2.011

Note. The variables are distributed according to the ranking suggested by the stepwise model.
$p \leq .05$*; R^2a = adjust correlation coefficient.

Table 7
Coefficient of Multiple Determinations and Beta Scores of the Regression Model for Semantic VFT

Variables	B	b	Standard Error
Education	.388*	.314	.074
Age	-.095*	-.219	.021
Sem. Julg. Exp.	.706*	.270	.148
Reading Writ. Freq.	.213*	.150	.074
Intercept = 14.371		R^2 =.444	
		R^2a =.436	
		R =.667	

$p \leq .05$**; R^2a = adjust correlation coefficient.

Comparing the three explanatory models of VFT performance showed by regressions, education had the greatest participation in predicting mean test performance scores and alone explained 23.3% to 30.9% of the total performance. Age had the greatest contribution to the free and semantic VFT, and its explanatory capacity ranged from 6.1% to 7.4% of the scores, whereas in the phonemic test, the same variable explained about 2.2% of the performances. The semantic judgment task (explanation score) predicted from 4.9% to 6.9% of the performances, and the reading and writing frequency score had, at the most, a contribution of 4.2% in the explanation of word generation.

However, the association of the four variables had a greater predictive capacity for the semantic VFT result and explained 43.6% of total performance, whereas the equations estimated 38% and 39.2% of the performances in the unconstrained and phonemic tests. These results suggest that there is contribution of other cognitive processes that may be evaluated more accurately using neuropsychological performance indices not included in this study.

Discussion

The variables under analysis were associated to each other in different ways and contributed at different levels to the performances in the types of VFT studied here. The hypothesis tested in this study was confirmed as education was the main variable to predict performance in the three VFT criteria, followed by the score in the semantic

judgment task. Less importantly, reading and writing frequency and age also predicted performance. Depression indices were not correlated with performance in word generation tasks, probably because the study sample did not include participants with more intense markers of this mood disorder.

Another important finding was the variance shared by education and reading and writing frequency or semantic judgment. Each variable contributed differently and had a greater or lesser participation in and prediction of performance in the generation of words after controlling the shared variance between the variables by using regression analysis. Therefore, this discussion will analyze the effect of education, followed by the effects of writing and reading, age and, finally, of semantic judgment.

Education had the greatest predictive effect on tasks, either alone or in interaction with the other variables. Individually, education explained 23% to 30% of the participants' capacity to generate words using the different VFT criteria. The other variables were associated with education, which increased the explanatory power of performance in the three criteria of word generation. Similar results were found in studies conducted in Latin American countries, whose populations also have heterogeneous educational levels (Ostrosky-Solis, Ardila, & Rosselli, 1999; Parente, Scherer, Zimmermann, & Fonseca, 2009; Rosselli & Ardila, 2003). Even in countries with greater socioeconomic development and a more uniform educational level, a study conducted with patients with hemispheric lesions found that the individuals with higher educational levels were grouped in the high performance cluster, regardless of anatomic site, type of lesion (Beausoleil et al., 2003) or the occurrence of Alzheimer's disease (Kawano et al., 2010). These results show that education has a complex effect on verbal fluency processing, even greater when associated with other sociocultural variables.

According to the regression models, reading and writing frequency definitely has a greater effect on the phonemic test, which may be explained by the same hypothesis of association between reading, literacy, greater metalinguistic awareness and larger vocabulary. Moreover, as VFTs require the generation of words, the cognitive skills demanded in reading practices may have a considerable effect on the lexical-semantic skills required in phonemic VFT.

Individuals with a higher educational level, in either the control or the study group, have a better performance in reading tests (Foss, Vale, & Speciali, 2005), which suggests that engagement in reading and writing may be more evident in individuals with more than two years of education. Reading and writing are activities of continued cognitive stimulation that may be present even when the individual is not doing any activities related to formal education. They are, in this sense, activities that contribute to the maintenance of neuropsychological skills and that favor the expansion of verbal and semantic knowledge. However, in a compensatory perspective, the engagement

of individuals in these activities may mitigate the impact of a low educational level or aging on tests that require verbal knowledge and semantic processing, as they contribute to the maintenance or enrichment of neuropsychological skills. Evidence in the literature shows that the effects of leisure time activities, pastimes and occupations in general on cognitive performance are positive (Annear, Cushman, & Gidlow, 2009).

Age has been one of the main variables in studies in the field of neuropsychology that take into consideration the cognitive changes of normal individuals along their vital cycle. However, in this study, only the unconstrained and the semantic VFTs showed an important contribution of age, which had, in all cases, a less important impact than schooling years. In phonemic VFT, the effect of age was overshadowed by semantic processing indices and reading and writing frequency. This result may suggest that the neuropsychological processing that underlies the performance of unconstrained and semantic tasks is more susceptible to the effects of ageing. Semantic processing, in addition to processing speed, cognitive flexibility, inhibition and other factors, are mental skills demanded for tasks that involve word generations based on semantic strategies, as is the case in unconstrained and semantic verbal fluency tasks (Beausoleil et al., 2003). In the literature, there are findings that suggest that these functions decline with ageing (Federmeier et al., 2002). However, in the phonemic task, age, even after its inclusion in the regression models, had a less important explanatory contribution to the performance of verbal fluency using this criterion. The analysis of phonemic VFT characteristics revealed that literacy and spelling knowledge are mandatory for task performance. Specifically for this criterion, education provides the knowledge associated with metalinguistic awareness, which is necessary to explore the lexical memory and select the possible correct answers accurately. Therefore, considering the demand of specific skills to explore lexical memory based on spelling (or phonological) strategies, the effects of education and reading and writing become more evident and overshadow the effects of age.

The demand for specific skills to explore lexical memory based on spelling (or phonological) strategies may count on the significant participation of lexical-semantic skills, controlled, in this study, by the performance of participants in the semantic judgment tasks. This hypothesis justifies the greater importance of the semantic processing variable than that of age in the phonemic task. Moreover, in the unconstrained and semantic tasks, the semantic processing index was part of the regression models as the variable of greatest importance immediately after education and age. Therefore, the results of this study support the argument according to which VFT may be classified as an integrity index of the skills associated with semantic processing (Brucki & Rocha, 2004). The impact of age was probably not greater because our study enrolled people until 75 years old as well as younger participants with a lower cognitive reserve.

The contribution of semantic judgment was greater in the phonemic VFT than in the tasks with other criteria. The retrieval of words from the lexical-semantic system may occur, primarily, by means of semantic strategies. The larger the semantic category accessed (or the greater the number of semantic categories available), the greater may be the probability that there may be more words with that letter that correspond to the lexical rule. Therefore, if the possibility of answers is greater, or if the semantic skills are better preserved, the time used to find the words will be shorter, which, therefore, may improve the performance in these tasks. In contrast, the greater contribution of age in predicting performance in semantic tasks than in phonemic tasks is in agreement with other studies, which suggested that semantic tasks are more sensitive to the effects of ageing (Szatkowska et al., 2000). In addition, there is evidence that different resources of executive functions are necessary to perform semantic VFTs, which activates frontal lobe regions (Kavé, 2005). Other studies confirmed the effect of age and education on semantic processing (Machado, Correia, & Mansur, 2007), which may justify the interaction between semantic judgment and the other variables.

This study found that education is the variable whicth better predict VFTs. Reading and writing frequency and lexical-semantic capabilities are associated and interact with education. The effect of age depends on the type of criterion used in VFTs, and is lower when the criterion is phonemic. These results stress the importance of considering that the different VFTs involve different combinations of cognitive resources, and should be analyzed separately when the aim is to make an accurate neuropsychological assessment.

The variables included in this study models did not explain all verbal fluency performances (predicted 39% to 44%), that is, the rest of the variance may be explained by other variables, not included in this study. VFTs involve a series of cognitive processes (Troyer, 2000; Zelazo, Müller, Frye, & Marcovitch, 2003), particularly those associated with lexical-semantic and executive processing (Elst et al., 2006; Lezak et al., 2004; Strauss, Sherman, & Spreen, 2006). More complex models may be capable of including, in future studies, task performance scores that examine components of executive functions, particularly inhibition and initiative (Capovilla, 2006; Henry & Phillips, 2006), attention and the central executive of the working memory (Baddeley, 2003; Elst et al., 2006; Lezak et al., 2004), and information processing speed and cognitive flexibility (Crawford, Bryan, Luszcz, Obonsawin, & Stewart, 2000; Hughes & Bryan, 2002; Hurks et al., 2006).

This study did not include specific markers of executive functioning, and future studies should validate the hypothesis that the performance in VFTs may only be classified as a marker of integrity of executive skills (as traditionally used) after impairment of lexical-semantic skills has been ruled out. If not, the results of performance in word generation tasks may be associated with possible impairment to lexical-semantic processing, alone or in combination with impaired executive processing. Further clustering and switching studies should be conducted to better understand the executive strategies inherent to the performance of VFTs in relation to sociodemographic and biological factors.

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