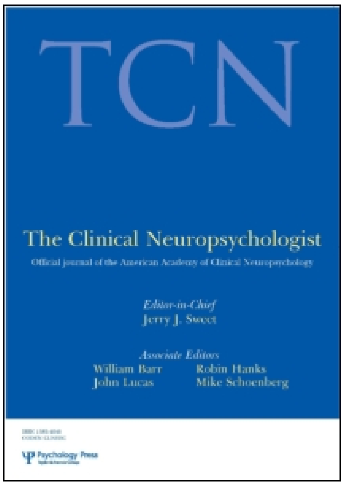

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Verbal Fluency in Spanish-Speaking Children: Analysis Model According to Task Type, Clustering, and Switching Strategies and Performance Over Time

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CE Verbal Fluency in Spanish-Speaking Children: Analysis Model According to Task Type, Clustering, and Switching Strategies and Performance Over Time

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Verbal fluency (VF) tasks are extensively used to measure strategic retrieval and executive functioning. Results for total production of words, clustering and switching strategies, and performance over time for Spanish-speaking children are provided. A total of 120 children, ranging in age from 8 to 11, were divided by age into two groups and evaluated. A higher total score for words produced in the semantic compared with the phonological task, a correlation between clustering and switching strategies and total score, and decreased task performance over time were evidenced. These scores were higher in the older group. Moreover, an association was found between verbal fluency tasks, strategies employed, and cognitive executive functions. This indicates that clustering and switching strategies provide indicators of strategic retrieval and executive processes. Together the results suggest that these fluency scores are valuable to measure underlying cognitive processes and retrieval strategies and therefore could be useful to assess executive function deficits in children.

Keywords: Verbal fluency; Cognitive strategies; Cognitive processing; Executive functions; Child neuropsychology.

INTRODUCTION

Verbal fluency (VF) tasks are among the most frequently used tests to measure executive function (Henry & Crawford, 2004; Phillips, 1997) and brain damage associated cognitive performance (Henry & Crawford, 2004; Ruff, Light, Parker, & Levin, 1997). Lezak (1995) defines verbal fluency as the number of words produced within a selected category in a limited period of time (60 seconds). Two major types of VF tasks can be distinguished: (a) semantic verbal fluency (SVF; searching for words within a category) and (b) phonological verbal fluency (PVF; producing words beginning with a given letter). The total number of words generated provides information not only about effectiveness of verbal retrieval and recall but also about executive function; performing verbal fluency tasks requires self-monitoring, effortful, inhibitory processes, initiation, and organizing an efficient search in the internal lexicon (Henry & Crawford, 2004; Ruff et al., 1997).

Although both categories apparently impose demands on executive processes (Henry & Crawford, 2004), semantic tasks seem to be simpler than

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phonological ones. In this sense, in previous studies carried out with children, it has been found that the number of words generated in the phonological tasks is less than those generated in the semantic tasks (Hurks et al., 2004, 2006; Nash & Snowling, 2008; Nieto, Galtier, Barroso, & Espinosa, 2008; Sauzéon, Lestage, Raboutet, N'Kaoua, & Claverie, 2004). This reality might be due to the fact that retrieval of words beginning with a specific letter requires the exploration of more subsets of categories than the recovery of words belonging to a certain category (Martins, Vieira, Loureiro, & Santos, 2007; Riva, Nichelli, & Devoti, 2000).

Previous studies based on adult populations have demonstrated differences as regards the performance of VF tasks according to lesion laterality (right hemisphere vs left hemisphere) and location (anterior vs posterior). Regarding the effects of laterality, it has been demonstrated that verbal fluency tasks are more sensitive to left frontal lesion than to right frontal lesion (Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001; Pendleton, Heaton, Lehman, & Hulihan, 1982). In turn, patients with left hemispheric lesion show a greater deficit in the task than patients with right hemispheric lesion (Pendleton et al., 1982). Martin, Loring, Meador, and Lee (1990) found lateralization effects on word fluency after temporal lobectomy, where left temporal patients performed significantly worse compared with right temporal patients. As for the location of the injury, it has been considered that patients with left frontal lesions present a greater deficit in the task than those with left temporal lesions (Milner, 1964). Similar to adult populations, children with left lesions show a poor performance on measures of lexical retrieval and word fluency compared with children with right lesions (Aram, Ekelman, & Whitaker, 1987; Levin, Song, Ewing-Cobbs, Chapman, & Mendelsohn, 2001). Moreover, Hernandez et al. (2002) observed that children with frontal lobe epilepsy perform less well on verbal fluency tasks than those children with temporal lobe epilepsy.

Studies have also indicated that the different types of VF, semantic or phonological, have different brain-based substrates (Jurado, Mataro, Verger, Bartumeus, & Junque, 2000). According to Martin, Wiggs, Lalonde, and Mack (1994), semantic tasks would be more dependent on temporal lobe function, while the phonological ones would impose greater demands on frontal lobe mediated strategic search processes. Nevertheless, a recent meta-analysis study has concluded that although the semantic fluency task is also sensitive to temporal lobe pathology, both types of verbal fluency, semantic and phonological, demonstrate the same sensibility as for the detection of frontal dysfunctions (Henry & Crawford, 2004).

Concerning the development of the VF in children, it has been demonstrated that performance in the task increases with age. Certain studies suggest that verbal fluency would reach adult levels around the age of 10 (e.g., Regard, Strauss, & Knapp, 1982). Anderson, Anderson, Northam, Jacobs, and Catroppa (2001) who worked with a sample of Australian children and teenagers from 11 to 17 years of age, did not find a significant effect of age in the verbal fluency task. Nevertheless, other authors suggest that verbal fluency continues developing during adolescence both in Hebrew-speaking children (Kavé, 2006) and in Finnish-speaking children (Klenberg, Korkman, & Lahti-Nuuttila, 2001). Similar results are found in Spanish-speaking children. For example, Matute, Rosselli, Ardila, and Morales (2004) analyzed the impact age had on 171 Spanish-speaking children between 6 and 15 years old concerning verbal and nonverbal fluency. The authors discovered an effect of age on both types of fluency with an increase in the performance of these tasks between 6 and 15 years old and normative values similar to those found in studies carried out in other countries.

In turn, it has been suggested that the development of VF differs according to the type of semantic or phonological fluency task. For example, Riva et al. (2000), who worked with a sample of 5- to 11-year-old Italian children, stated a greater effect of age on semantic fluency tasks than on phonological ones. In addition they observed that changes in the SVF would occur mainly between the ages of 5 and 7. Sauzéon et al. (2004) found stability of semantic fluency performance from the age of 12 and a constant progress of phonological fluency from 7 to 16 years old. This plateau in SVF by the age of 13 and an increase in phonemic fluency during adolescence were also demonstrated in a sample of Portuguese-speaking children (Martins et al., 2007). Hence, although it is established that performance on VF tasks is sensitive to neurodevelopment, it is not yet determined at which age it would reach the level of adult performance (Cohen, Morgan, Vaughn, Riccio, & Hall, 1999).

A wide range of research using verbal fluency tasks both in child and in adult populations has suggested their efficacy not only as a measure of the search and retrieval of words within a category, but also in analyzing automatic versus controlled cognitive processes underlying the task as a function of time interval, and in analyzing the use of clustering and switching organizational strategies.

As regards the analysis of word production as a function of time, empirical studies have found that the number of words produced on letter and semantic fluency changes noticeably over time (Crowe, 1998; Fernaeus & Almkvist, 1998; Hurks et al., 2004, 2006; Raboutet et al., 2010). This change can be documented from approximately the first 15–20 seconds to the last 40–45 seconds over a period of 1 minute, as evidenced by a decreased performance in verbal fluency task as the seconds go by. This may be explained by the fact that in the first period (15–20 seconds) a ready pool of frequently used words seems to be available and is automatically triggered for production; as time goes by (40–45 seconds), however, the pool becomes exhausted and production becomes more effortful and less productive (Crowe, 1998; Hurks et al., 2006). It has been suggested that this analysis provides additional insight into automatic and controlled cognitive processes (Hurks et al., 2004, 2006). Automatic processes are characterized by unawareness; they are activated automatically and require no active control, whereas controlled processes are activated under control, and require higher effort and attention demand (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977).

In addition, the use of verbal fluency tasks may be optimized by the analysis of clustering and switching cognitive strategies employed. These would be used during word generation, because in normal populations there is a trend to recall words clustered in subcategories. Then, when this clustering becomes exhausted, effective performance involves switching to a new subcategory (Troyer, 2000; Troyer, Moscovitch, & Winocur, 1997). As these strategies would optimize word search in the internal lexicon, they would correlate with the total word production score. It has been suggested that these strategies would involve different cognitive processes. Clustering would depend on phonemic analysis in PVF and on categorization and semantic memory ability in SVF, while switching would depend on cognitive flexibility and the ability to alternate attention focus (Troyer, 2000; Troyer et al., 1997). Moreover, these components of fluency would depend on different brain regions. Clustering would be associated with temporal lobe function and switching with frontal lobe functioning (Troyer, Moscovitch, Winocur, Alexander, & Stuss, 1998). Studies conducted in adult populations have suggested a significant effect of education (Brucki & Rocha, 2004; Kosmidis, Vlahou, Panagiotaki, & Kiosseoglou, 2004; Rosselli, Tappen, Williams, Salvatierra, & Zoller, 2009; Troyer, 2000; Villodre et al., 2006) and age (Brucki & Rocha, 2004; Kosmidis et al., 2004; Troyer et al., 1997) on the number of words generated and the number of clustering and switching strategies. Likewise, studies performed with child populations have found differences in the number of strategies used as a function of age (Kavé, Kigel, & Kochva, 2008; Koren, Kofman, & Berger, 2005; Nieto et al., 2008; Sauzéon et al., 2004).

Despite the increasing interest in the employment of qualitative analysis of VF tasks in children of different countries and languages, there are few normative studies carried out in Spanish-speaking children. Nieto et al. (2008) performed a normative study in 79 Spanish-speaking children from 6 to 11 years of age, analyzing the total production of words in the semantic (animals) and phonological (letters F, A, and M) fluency tasks and the number of clustering and switching strategies used according to age. They reported that the total number of words generated in the SVF and PVF and the number of clusters and switches increase with age; on the contrary, this will not occur as regards mean cluster size.

Within the scope of clinic, the performance on the verbal fluency tasks can be affected by several causes. Specifically, this has been appreciated in children with attention deficit hyperactivity disorder (Pineda, Ardila, & Rosselli, 1999; Pineda et al., 1998), rolandic epilepsy (Lindgren et al., 2004), head injury (Levin et al., 2001; Slomine et al., 2002), fetal alcohol syndrome (Kodituwakku et al., 2006; Schonfeld, Mattson, Lang, Delis, & Riley, 2001) Down's syndrome (Nash & Snowling, 2008), and dyslexia (Cohen et al., 1999; Reiter, Tucha, & Lange, 2005), among others. The former studies have demonstrated that the total number of words generated enables discrimination between children with different developmental or acquired disorders and controls; but the effectiveness of the qualitative analysis of the task and over time for the evaluation and the differential diagnosis of distinct infant neuropsychological disorders has also been proved. For example, Hurks et al. (2004) found that the differences in performance on the verbal fluency tasks between children of 9 years of age with ADHD and a control group reside in the quantity of words generated in the first 15 seconds of the PVF, but not in the total number of words produced within 60 seconds. These authors concluded that the differences are due to a delay in the development of the automatic skills in order to process verbal abstract information. Thus they indicate that the analysis of VF according to time is necessary for clinical evaluation, since it permits one to distinguish between children with ADHD and controls. In addition, a recent study carried out with children with Down's syndrome (DS) and control children, who were matched pairwise for receptive vocabulary age, found differences in the total number of words generated in the SVF and the PVS, the number of clusters used, but not as regards clusters size (Nash & Snowling, 2008). According to these authors, this fact might reflect that children with Down's syndrome present less-effective recovery strategies rather than differences in the organization of linguistic representations. Taken together, these findings suggest that these score methods are a valuable tool for the assessment and differential diagnosis of infantile disorders, particularly those who present a neurocognitive pattern of executive dysfunction. Therefore the results from this study could be useful for the pediatric neuropsychological clinic to assess executive function deficits in children with developmental or acquired neurological disorders.

In summary, verbal fluency tasks are very valuable in the clinical setting as they make possible the evaluation of the different cognitive processes and strategies involved, such as (a) the study of different types of fluency, semantic and phonological, that would be associated with different brain structures and would differ in terms of "effort"; (b) performance on the task as a function of time, which provides a measure of underlying (automatic vs controlled) cognitive processes; and (c) the analysis of clustering and switching strategies, which provides indicators of lexico-semantic knowledge, strategic retrieval and executive processes.

Although several studies have already been carried out with pediatric populations examining the effect of age on VF tasks, to our knowledge this score method has not yet been fully investigated in Spanish-speaking children. A better understanding of cultural and linguistic influence on this analysis and further evidence of cross-language validity of verbal fluency tests could be obtained by means of a Spanish sample. For that reason, this work aims to present preliminary normative data by analyzing the total score of words generated, and clustering and switching strategies used, and performance over time in Spanish-speaking children. To this end we investigated a group of healthy children aged 8 through 11 years. Previous studies have analyzed clustering strategies (Koren et al., 2005) and performance over time (Hurks et al., 2006) in children between these ages. According to Koren et al. (2005) children between 8 and 11 years old would already be proficient in reading and show an output sufficient to combine into clusters. Besides, considering the age range they belong to, they manifest a constant improvement in VF. A further aim of this investigation was to examine the influence of cognitive executive processes and verbal memory (effective recall strategies) on VF performance and on organizational strategies.

METHOD

Participants

The sample consisted of 120 participants living in the city of Santa Fe, Argentina, distributed in two age groups (see Table 1):

- *Group 1*. A total of 68 children ages 8 to 9 years ($M = 8.57$, $SD = 0.498$), of whom 31 were girls and 37 were boys.
- *Group 2*. A total of 52 children ages 10 to 11 years ($M = 10.48$, $SD = 0.505$), of whom 21 were girls and 31 were boys.

The children were monolingual native Spanish speakers. From the information collected at school and from the parents or guardians, the children met the following inclusion criteria: (1) had no clinical, neurological, or psychiatric history;

Table 1 Demographic characteristics of the sample

	Age group	
	Group 1 aged 8–9	Group 2 aged 10–11
Number of participant	68	52
Age (mean ± *SD*)	8.57 (0.49)	10.48 (0.50)
Grade level	3–4	5–6
Gender	31 F/37 M	21 F/31 M
General IQ (mean ± *SD*)	97.07 (7.91)	90.52 (6.38)

(2) attending school on a regular basis; (3) had no grade repetition and no need of corrective programs; and (4) attending a middle class neighborhood school of the city. The Department of Education suggests certain socioeconomic coefficient that is determined on the basis of family income, establishing a scale that goes from *very good* to *deficient* (source: Computer system of the Department of Education of the Province of Santa Fe, Argentina). The socioeconomic coefficient of the school, based on family income, was "good." According to this classification *good* refers to those families that count with paid jobs and fixed salaries. In addition, parents' education data was collected by means of a scale that goes from 1 to 5. The different educational levels were classified as: (1) Primary level, (2) Secondary level, (3) More education than secondary school but less than a university degree, (4) University degree, (5) Master degree or higher education. The average of fathers' education was 3.00 (0.69) while the average of mothers' education was 2.67 (0.80). Most parents had completed their secondary or university level education.

Before task administration, all children were administered the Kaufman Brief Intelligence Test (K-BIT) (Kaufman & Kaufman, 1990/2000) as a screening measure of intellectual abilities. Intellectual performance fell within the normal expected range for their age ($M = 94.23$, $SD = 7.96$).

Measures

Core neuropsychological instruments

K-BIT, Kaufman Brief Intelligence Test. This test (Kaufman & Kaufman, 1990, Spanish adaptation by Cordero & Calonge, 2000) measures verbal and non-verbal intelligence, and consists of two subtests: Vocabulary and Matrices. By summing up the scores obtained in both subtests, a measure of general intelligence can be elicited.

d2, Test of Attention. This test (Brickenkamp, 1962, Spanish adaptation by Seisdedos, 2004) measures processing speed, rule compliance, selective attention, and concentration performance. The test is made up of 14 lines, each with 47 characters, for a total of 658 items. Each character consists of a letter "d" or "p" marked with one, two, three, or four small dashes arranged either individually or in pairs above and below the letter. The participant is required to scan across each line to identify and cross out all occurrences of the letter "d" with two dashes.

These items are the "relevant items" while other combinations of letters and lines are considered "irrelevant." The participant is allowed 20 seconds per line.

WISC-IV Digit Span and Letter–Number Sequencing subtest (Wechsler Intelligence Scale for Children – Fourth Edition). The Working Memory Index (WMI) (Wechsler, 2003, Spanish Adaptation TEA, 2005) is composed of two subtests: Digits Span (DS) and Letter–Number Sequencing (LN). Digit Span consists of two parts: Digit Forward task and Digit Backward task. Letter–Number Sequencing consists of 10 items of three trials each. This task involves retention and active manipulation of information.

Wisconsin Card Sorting Test (WCST). The WCST (Heaton, Chelune, Talley, Kay, & Curtiss, 1993, Spanish Adaptation TEA, 1997) provides a measure of executive function, particularly "cognitive flexibility" and "categorization ability."

Stroop Color-Word Interference Test. This test (Golden, 1978, Spanish Adaptation TEA, 1999) provides a measure of "interference" and "selective attention." The task includes three conditions: (a) the word condition, (b) the color condition, and (c) the color-word condition. The validity of the Stroop test as a measure of interference control and selective attention has been established in numerous studies (for a review, see MacLeod, 1991).

Rey Auditory-Verbal Learning Test (RAVLT). The RAVLT (Rey, 1964) evaluates the acquisition and retention of verbal material and verbal associative learning. It measures immediate memory span, provides a learning curve, and reveals learning strategies (Lezak, 1995).

Instruments under evaluation

Semantic (fruits and animals) and Phonological (letters F, A, and S) Verbal Fluency Test. The test consists in asking the participant to recall all possible words belonging to a given category (SVF) or starting with a given letter (PVF) within 60 seconds, excluding proper names and alternate endings of the same word. Repetitions and intrusions were also excluded from the number of correct words generated. The analysis of strategies used was performed according to the scoring rules proposed by Troyer et al. (1997) and Troyer (2000). The indicators used to score verbal fluency task are shown in Table 2.

Ethical procedure

Requests for interviews were made with the school principals, who then received explanations regarding the investigation. The authorization of the children's parents or legal tutors was then sought, clarifying that the participation was deliberate and anonymous. Finally, parental or legal tutor written consent was obtained for each child participating in the study. Each child was tested individually and within the school area for three sessions lasting up to 30 minutes per session.

Table 2 Indicators used to score verbal fluency task

Scoring method			
Task type	Time interval	Organizational strategies: Calculated according to the scoring rules defined by Troyer et al. (1997) and Troyer (2000).	
Semantic (SVF)	The production for each 15-s time slice on each task (SVF and PVF) was recorded as follows:	*Clusters:* clusters consisted of successively generated words belonging to the same semantic or phonological subcategory.	
Total score animals		*Semantic clusters*	*Phonological clusters*
Total score fruits		*Animals:* domestic animals, sea animals, reptiles, insects, flying animals, etc. And pairs of words associated by cultural influence (for example, elephant–mouse).	Words that rhyme
Total score SVF			Words starting with the same two first letters or syllable
Phonological (PVF)	*0–15 seconds*		Start–end: words starting and ending with the same sound
Total score letter F	*16–30 seconds*	*Fruits:* winter fruits (citric), spring and summer fruits, dry fruits.	Homonyms
Total score letter A	*31–45 seconds*	*Cluster size:* calculated by counting from the second word, excluding isolated words (for example, 3 words form a size 2 cluster). This was computed for each subtask and an overall average was obtained for each SVF and PVS task type.	
Total score letter S	*46–60 seconds*	*Number of switches:* calculated by the number of switches or changes between clusters, including isolated words (for example, two clusters and three isolated words sum up four switches)	
Total score PVF			

Statistical analysis

Bifactorial multivariate analyses of variance (MANOVA) were performed to assess the effect of age, sex, and their interaction on different fluency measures, performance over time, and the use of clustering and switching strategies. Partial Eta squared was used to determine the effect size of multivariate and univariate *F*s. Compliance with homogeneity of variance assumption was confirmed before analysis. The association degree between variables was calculated using Pearson's correlation coefficient. Finally, stepwise regression analyses were used to determine the relative contributions of cognitive strategies to explaining the variance in VF measures. Data processing and statistical analysis were performed using the Statistical Package for the Social Sciences (SPSS) version 15.0, and a statistical significance level below .05 was set.

RESULTS

Performance in SVF and PVF tasks by age and sex

For the SVF, significant effects for the age factor were found (Hotelling's $T = 0.248$), $F(2, 115) = 14.287$, $p < .000$, partial $\eta^2 = 0.199$, but no significant effect was found for the sex factor (Hotelling's $T = 0.005$), $F(2, 115) = 0.316$, $p < .730$, partial $\eta^2 = 0.005$, and for the interaction between the two (Hotelling's $T = 0.046$) $F(2, 115) = 2.665$; $p < .074$, partial $\eta^2 = 0.044$. An effect of age factor was observed on total production of words, $F(1, 116) = 25.249$; $p < .000$, partial $\eta^2 = 0.179$, as well as on the category Animals, $F(1, 116) = 13.735$; $p < .000$, partial $\eta^2 = 0.106$, and the category Fruits, $F(1, 116) = 23.680$; $p < .000$, Partial $\eta^2 = 0.170$.

For the PVF, significant effects were found for both the age factor (Hotelling's $T = 0.368$), $F(3, 114) = 14.002$; $p < .000$, partial $\eta^2 = 0.269$, and the sex factor (Hotelling's $T = 0.199$), $F(3, 114) = 7.569$; $p < .000$, partial $\eta^2 = 0.166$. No differences were found for the interaction between the two (Hotelling's $T = 0.069$), $F(3, 114) = 2.634$; $p < .053$, partial $\eta^2 = 0.065$. A significant effect of age factor was observed on the total score, $F(1, 116) = 24.864$; $p < .000$, partial $\eta^2 = 0.177$, and the number of words produced with the letter F, $F(1, 116) = 40.362$; $p < .000$, partial $\eta^2 = 0.258$, the letter A, $F(1, 116) = 7.833$; $p < .006$, partial $\eta^2 = 0.063$, and the letter S, $F(1, 116) = 13.993$; $p < .000$, partial $\eta^2 = 0.108$. Sex differences for the letter F, $F(1, 116) = 10.036$; $p < .002$, partial $\eta^2 = 0.080$, favoring girls were observed.

Overall, children were shown to produce more words in the SVF task ($M = 21.00$, $DS = 4.97$) than in the PVF task ($M = 17.84$, $DS = 6.64$). As regards the total number of words generated according to age, significant differences favoring the older group were found. The analysis of means shows that the number of words produced over time significantly differs in both tasks. Children produce more words during the first 15 seconds, and the number of words decreases at subsequent time intervals both in SVF and in PVF tasks. These scores were higher in the older group (see Table 3).

Table 3 Descriptive statistics (mean ± *SD*) of semantic and phonological tasks by time and use of strategies

		Age Group (n)	0–15	16–30	31–45	46–60	Total	Clusters	Size	Switches
SVF	Animals	1 (68)	5.46 ± 1.68	2.71 ± 1.45	1.94 ± 1.23	1.90 ± 1.47	12.00 ± 3.26	3.19 ± 1.23	2.12 ± 0.99	4.72 ± 2.11
		2 (52)	6.37 ± 1.46	3.23 ± 1.39	2.50 ± 1.46	2.12 ± 1.35	14.21 ± 3.64	3.73 ± 1.10	2.05 ± 0.79	5.94 ± 1.96
	Fruits	1 (68)	4.72 ± 1.33	1.44 ± 1.05	0.68 ± 0.87	0.44 ± .78	7.28 ± 1.93	2.07 ± 0.83	1.69 ± 0.72	2.84 ± 1.26
		2 (52)	5.46 ± 1.24	2.23 ± 1.33	0.75 ± 0.86	0.60 ± .95	9.04 ± 2.28	2.38 ± 0.88	2.06 ± 0.84	3.17 ± 1.53
	Total	1 (68)	10.18 ± 2.40	4.15 ± 2.03	2.62 ± 1.55	2.34 ± 1.72	19.28 ± 4.20	5.26 ± 1.60	1.91 ± 0.62	7.56 ± 2.65
		2 (52)	11.83 ± 2.14	5.46 ± 2.11	3.25 ± 1.78	2.71 ± 1.80	23.25 ± 5.04	6.12 ± 1.59	2.06 ± 0.53	9.12 ± 2.90
PVF	Letter F	1 (68)	2.10 ± 1.14	1.25 ± 0.83	0.79 ± 0.74	0.76 ± 0.79	4.91 ± 1.76	0.66 ± 0.68	0.69 ± 0.76	2.96 ± 1.67
		2 (52)	3.40 ± 1.22	1.71 ± 1.14	1.12 ± 0.92	0.98 ± 0.89	7.21 ± 2.72	1.19 ± 0.79	0.99 ± 0.62	4.71 ± 2.30
	Letter A	1 (68)	2.41 ± 1.36	1.19 ± 0.95	1.13 ± 0.87	0.91 ± 1.03	5.65 ± 2.58	1.12 ± 0.92	0.98 ± 0.74	3.00 ± 1.68
		2 (52)	2.83 ± 1.11	1.67 ± 1.15	1.27 ± 0.97	1.06 ± 1.14	6.83 ± 2.48	1.35 ± 0.76	1.25 ± 0.64	3.87 ± 2.07
	Letter S	1 (68)	1.99 ± 1.09	1.04 ± 0.90	1.12 ± 0.89	0.91 ± 1.06	5.06 ± 2.37	1.06 ± 0.82	1.07 ± 0.79	2.47 ± 1.81
		2 (52)	2.48 ± 1.16	1.83 ± 0.98	1.06 ± 0.95	1.35 ± 1.37	6.71 ± 2.85	1.62 ± 1.03	1.13 ± 0.69	3.42 ± 1.99
	Total	1 (68)	6.50 ± 2.41	3.49 ± 1.67	3.04 ± 1.72	2.59 ± 1.91	15.62 ± 5.66	2.84 ± 1.92	0.91 ± 0.50	8.43 ± 3.96
		2 (52)	8.71 ± 2.62	5.21 ± 2.31	3.44 ± 1.92	3.38 ± 2.59	20.75 ± 6.76	4.15 ± 1.67	1.12 ± 0.38	12.00 ± 5.01

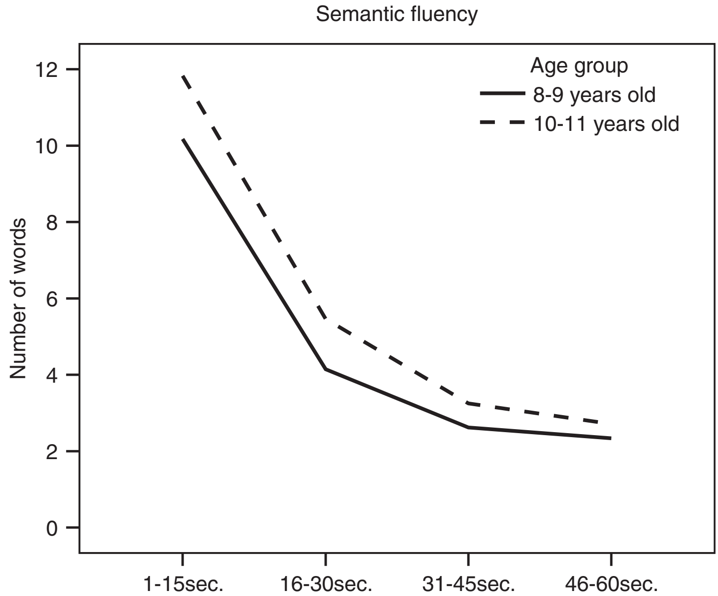

Figure 1 Mean SVF task scores (animals and fruits) by age group and time interval.

Performance in SVF and PVF total score over time by age and sex

The scores of each subtest were summed up to obtain an overall measure over time for the SVF (fruits and animals) and PVF (letters F, A, and S) tasks by age and sex.

For the SVF task, significant effects for the age factor were found (Hotelling's $T = 0.277$), $F(4, 113) = 7.817$; $p < .000$, partial $\eta^2 = 0.217$, but not for the sex factor (Hotelling's $T = 0.006$), $F(4, 113) = 0.180$; $p < .948$, partial $\eta^2 = 0.006$, or for the interaction between the two (Hotelling's $T = 0.048$), $F(4, 113) = 1.362$; $p < .252$, partial $\eta^2 = 0.046$.

For the PVF task, significant effects for the age factor were found (Hotelling's $T = 0.333$), $F(4, 113) = 9.412$; $p < .000$, partial $\eta^2 = 0.250$, but not for the sex factor (Hotelling's $T = 0.063$), $F(4, 113) = 1.772$; $p < .139$, partial $\eta^2 = 0.059$, or for the interaction between the two (Hotelling's $T = 0.046$), $F(4, 113) = 1.312$; $p < .270$, partial $\eta^2 = 0.044$.

Figures 1 and 2 show the performance for each age group by time interval, according to SVF (animals and fruits) and PVF (letters F, A, and S) total scores.

Organizational strategies by age and sex

Significant effects were found for both the age factor (Hotelling's $T = 0.300$), $F(6, 111) = 5.543$; $p < .000$, partial $\eta^2 = 0.231$, and the sex factor (Hotelling's $T = 0.131$), $F(6, 111) = 2.425$; $p < .031$, partial $\eta^2 = 0.116$. No differences were found for the interaction between the two (Hotelling's $T = 0.087$), $F(6, 111) = 1.617$; $p < .149$, partial $\eta^2 = 0.080$.

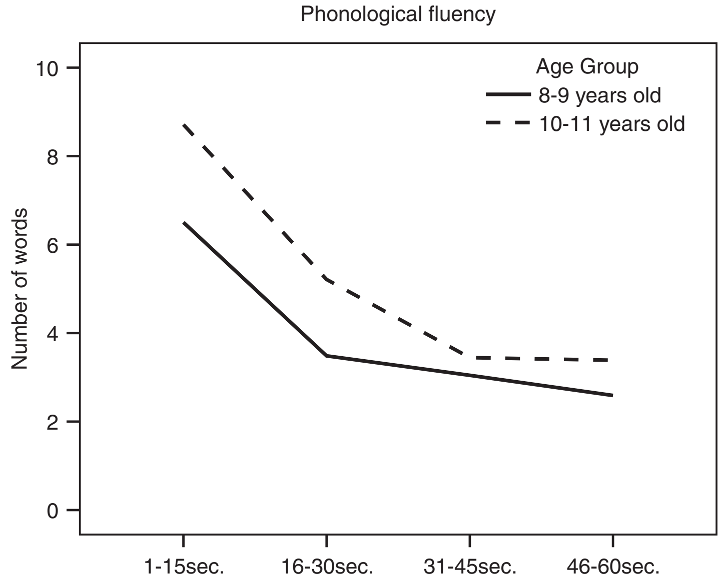

Figure 2 Mean PVF task scores (letters F, A, and S) by age group and time interval.

For the SVF task, the data suggest significant differences favoring the older group in terms of the number of clusters, $F(1, 116) = 10.151$; $p < .002$, partial $\eta^2 = 0.080$, and the number of switches, $F(1, 116) = 10.979$; $p < .001$, partial $\eta^2 = 0.086$. No differences in terms of cluster size were found, $F(1, 116) = 1.462$; $p < .229$, partial $\eta^2 = 0.012$. Sex differences for semantic cluster size, $F(1, 116) = 4.124$; $p < .045$, partial $\eta^2 = 0.034$, favoring boys were observed.

For the PVF task, the data suggest significant differences favoring the older group in terms of number of clusters, $F(1, 116) = 17.151$; $p < .000$, partial $\eta^2 = 0.129$, number of switches, $F(1, 116) = 24.468\, p < .000$, partial $\eta^2 = 0.174$, and cluster size, $F(1, 116) = 5.914$; $p < .017$, partial $\eta^2 = 0.049$. Sex differences for the number of phonological switches, $F(1, 116) = 6.187$; $p < .014$, partial $\eta^2 = 0.051$, favoring girls were observed.

Correlations among organizational strategies and total SVF and PVF scores

Pearson correlations were performed to assess the relationship between the total number of words produced in SVF and PVF tasks and the use of different strategies (see Table 4). For the SVF task, the number of words produced was positively correlated with the number of clusters ($r = .727$) and the number of switches ($r = .714$). For PVF tasks, the number of words produced was positively correlated with the number of clusters ($r = .775$), the number of switches ($r = .918$), and cluster size ($r = .505$).

Table 4 Correlations between (phonemic and semantic) clustering and switching strategies and total production of words for each task

	Semantic fluency				Phonological fluency			
	Total production	Clusters	Cluster size	Switches	Total production	Clusters	Cluster size	Switches
Semantic fluency								
Total production	—	.727(**)	.059	.714(**)	.626(**)	.471(**)	.248(**)	.610(**)
Clusters	.727(**)	—	−.284(**)	.457(**)	.435(**)	.357(**)	.212(*)	.378(**)
Cluster size	.059	−.284(**)	—	−.364(**)	.089	.057	−.044	.108
Switches	.714(**)	.457(**)	−.364(**)	—	.534(**)	.366(**)	.242(**)	.531(**)
Phonological fluency								
Total production	.626(**)	.435(**)	.089	.534(**)	—	.775(**)	.505(**)	.918(**)
Clusters	.471(**)	.357(**)	.057	.366(**)	.775(**)	—	.690(**)	.547(**)
Cluster size	.248(**)	.212(*)	−.044	.242(**)	.505(**)	.690(**)	—	.242(**)
Switches	.610(**)	.378(**)	.108	.531(**)	.918(**)	.547(**)	.242(**)	—

*$p < .05$; **$p < .01$.

Multiple regressions

Stepwise regression analyses were used to examine the contribution of number of clusters, switches, and cluster size to prediction in each fluency task. For SVF, number of clusters has the stronger predictive value and explained 52% of the variance, followed by number of switches (additional 18%), and cluster size (additional 16%). For PVF number of switches was the strongest predictor and accounted for 84% of the variance, number of clusters explained an additional 10%, and cluster size an additional 0.9%. The final models predicted 88% of the variance of the dependent variable in the semantic fluency and 95% of the variance in the phonological fluency (see full results in Table 5).

Correlations among organizational strategies, total SVF and PVF score, and cognitive functions

Total score for SVF was positively correlated with Stroop word naming ($r = .362$), Stroop color naming ($r = .343$), and Stroop color-word sheet ($r = .376$), attentional control ($r = .305$), and concentration ($r = .257$) of the D2 test, digit span ($r = .369$), letter–number sequencing ($r = .441$), and working memory index ($r = .460$) of the WISC IV test, immediate ($r = .326$) and delayed verbal memory ($r = .397$) of the AVLT test, and number of categories completed ($r = .197$) of the WCST test. In terms of strategies used, the number of clusters was positively correlated with Stroop word naming ($r = .237$), Stroop color naming ($r = .191$), Stroop color-word ($r = .259$), digit span ($r = .254$), letter-number sequencing ($r = .250$), working memory index ($r = .287$), and delayed semantic memory ($r = .245$). The number of switches correlated with all analyzed functions except for Stroop color naming. Cluster size correlated only with Stroop color naming

Table 5 Stepwise regression full results on each verbal fluency task

Variables	β	ANOVA for model	*R2*	*R2 change*
Semantic fluency				
Step 1				
Clusters	0.727**	$F(1, 118) = 132.373$**	0.529	0.529
Step 2				
Clusters	0.506**	$F(2, 117) = 145.491$**	0.713	0.185
Switches	0.483**			
Step 3				
Clusters	0.573**	$F(3, 116) = 287.350$**	0.881	0.168
Switches	0.614**			
Cluster size	0.445**			
Phonological fluency				
Step 1				
Switches	0.918**	$F(1, 118) = 631.490$**	0.843	0.843
Step 2				
Switches	0.705**	$F(2, 117) = 1090.547$**	0.949	0.107
Clusters	0.390**			
Step 3				
Switches	0.730**	$F(3, 116) = 874.853$**	0.958	0.009
Clusters	0.286**			
Cluster size	0.131**			

**$p < .001$.

($r = .302$). For PVF, both total word score and number of strategies used correlated with all analyzed cognitive functions except for the number of WCST categories completed and for switching and Stroop color naming. Cluster size correlated only with Stroop word naming ($r = .328$), Stroop color-word ($r = .220$), letter-number sequencing ($r = .318$), working memory index ($r = .273$), and immediate verbal memory ($r = .218$) (see Table 6).

DISCUSSION

The aim of this investigation was to evaluate the performance of Spanish-speaking children on verbal fluency tasks using a scoring method that provides a measure of different types of tasks, either semantic or phonological, underlying cognitive processes and clustering and switching strategies employed according to age. A further purpose of this work was to study the influence of cognitive executive processes and verbal memory on VF performance and on organizational strategies.

First, when word production is analyzed by task type (SVF vs PVF) children obtain higher scores in terms of the total number of words produced in the SVF task compared with the PVF task. This suggests that word generation according to the phonological principle (PVF) implies more searching effort and provides empirical evidence to the hypothesis that propose that PVF task demands more "effort" and it would be more "difficult" than the SVF task (Hurks et al., 2004, 2006;

Table 6 Correlations between (phonemic and semantic) clustering and switching measures with neuropsychological tasks

	Semantic fluency				Phonological fluency			
	Total production	Clusters	Switches	Cluster size	Total production	Clusters	Switches	Cluster size
Stroop test								
Word naming	0.362(**)	0.237(**)	0.258(**)	0.111	0.365(**)	0.370(**)	0.305(**)	0.328(**)
Color naming	0.343(**)	0.191(*)	0.149	0.302(**)	0.216(*)	0.253(**)	0.165	0.118
Word-color sheet	0.376(**)	0.259(**)	0.238(*)	0.149	0.272(**)	0.277(**)	0.181(*)	0.220(*)
D2								
Attentional Control	0.305(**)	0.118	0.274(**)	0.101	0.370(**)	0.284(**)	0.357(**)	0.132
Concentration Performance	0.257(**)	0.111	0.329(**)	–0. 047	0.316(**)	0.225(*)	0.325(**)	0.106
WISC IV								
Digit Span	0.369(**)	0.254(**)	0.337(**)	0.022	0.342(**)	0.288(**)	0.306(**)	0.169
Letter-Number Sequencing	0.441(**)	0.250(**)	0.369(**)	0.114	0.378(**)	0.353(**)	0.338(**)	0.318(**)
WM Index	0.460(**)	0.287(**)	0.401(**)	0.075	0.409(**)	0.364(**)	0.336(**)	0.273(**)
RAVLT								
RAVLT-Immediate	0.326(**)	0.153	0.297(**)	0.078	0.394(**)	0.305(**)	0.355(**)	0.218(*)
RAVLT-Delayed	0.397(**)	0.245(**)	0.283(**)	0.110	0.395(**)	0.286(**)	0.386(**)	0.168
WCST								
Categories complete	0.197(*)	0.141	0.202(*)	–0.059	0.098	0.079	0.123	0.104

$^*p < .05$; $^{**}p < .01$.

Riva et al., 2000). A possible explanation has been proposed as a function of language organization. Because the generation of words based on a *phonemic/* orthographic criterion is unusual, phonological tasks require suppressing the habit of using words in a way related to their meaning (Perret, 1974) and greater effort in terms of searching. Conversely, since semantic fluency search is consistent with the normal language organizational structure, and it is primarily based on semantic associations and meaning of words, specific inhibitory processes would not be required, leading to an easier retrieval of words. According to Riva et al. (2000) the major difficulty of phonological tasks would lie in the fact that they demand major organizational and strategic capabilities and depend on the maturation of the frontal lobe. Supporting this hypothesis of different processes involved in each condition, neuroimaging studies have shown the activation of different brain areas according to the semantic or phonological task type. Semantic fluency tasks would be more dependent on temporal lobe regions while phonological tasks would preferentially activate frontal lobe regions (Baldo, Schwartz, Wilkins, & Dronkers, 2006; Martin et al., 1994; Mummery, Patterson, Hodges, & Wise, 1996). Moreover, Szatkowska, Grabowska, and Szymanska (2000) found that the phonological and semantic fluency are mediated by different cerebral regions of the prefrontal cortex; the phonological fluency would be influenced by the left dorsolateral prefrontal cortex, while the semantic fluency might depend on the left and right dorsolateral prefrontal cortex and the right ventromedial areas.

Second, when the performance on the task over time is analyzed, a decreased number of words produced is observed starting from 16 seconds. Consistent with previous studies performed in children (Hurks et al., 2004, 2006) and healthy adults (Crowe, 1998), these data suggest greater effort and cognitive demand as from 16 seconds, in line with the hypothesis that as time elapses a systematic search in the internal lexicon, demanding controlled processing, and more executive function and attention effort, are required. No sex differences in the total score of words generated in SVF and PVF tasks and performance over time were found. Previous studies have shown similar results (Hurks et al., 2006; Nieto et al., 2008; Riva et al., 2000).

As regards cognitive strategies used, correlation analyses suggest that clustering and switching strategies are positively associated with the total number of words produced in both VF tasks. These data suggest that both clustering and switching are necessary to account for variations in the number of words produced (Troyer, 2000; Troyer et al., 1997). Hence, search and effective generation of words involve core cognitive processes such as clustering and switching strategies, which, by operating in conjunction, would optimize task performance. When the strategies employed in relation to SVF tasks were studied, a correlation between clusters and switching strategies and total score was observed. However, we did not find a significant association between semantic cluster size and the total number of words generated. For PVF tasks, our results indicate that the total score was more associated with the number of switches than with the number of clusters and with phonemic cluster size. These findings suggest that in the ages evaluated, the number of clusters and switches are more important than cluster size for an optimal performance on VF tasks and are congruent with the results reported in previous developmental studies conducted in Spanish (Nieto et al., 2008) and Hebrew

(Koren et al., 2005). Besides, stepwise regression analysis showed that although all components account for both VF tasks, number of clusters accounts for 52% of the variance for semantic fluency while number of switches accounts for 84% of the variance for phonological fluency. Our results indicate that number of clusters would the most important contributor to word recall by semantic principle, while, as reported in previous studies, change or switching strategies would be predominant in word generation by phonological principle (Troyer et al., 1997; Villodre et al., 2006). Thus word generation within the semantic field would occur in terms of semantic clusters that are related to semantic memory and temporal lobe functioning, whereas word generation on phonemic fluency would be produced mainly in the form of switches, which are related to cognitive flexibility and executive retrieval strategies, all these dependent on frontal lobe functioning. Since word generation within a given semantic category is consistent with the way language is organized, clustering words in semantic subcategories would be a more automatic and usual process. Besides, school teaching and transmission of knowledge are likely to play an overall role, due to the higher emphasis placed on the educational task in relation to teaching of words clustered in semantic categories.

As regards age differences, higher scores were found in the older group in terms of total words produced, performance over time, and number of clustering and switching strategies. The data obtained in our study, by means of the scoring method selected, are consistent with normative previous studies. With reference to the total number of words generated in the SVF, measured by the category "animals," children between 8 and 9 years old can generate about 12 words in a period of 1 minute and those between 10 to 11 years old are able to produce 14–15 words. Similar to Kavé's (2006) findings, both groups of age showed lower production of words in the category "fruits." Our results in the SVF task as regards Spanish-speaking children from Argentina are analogous to data in previous studies conducted with Spanish-speaking children from other countries (Matute et al., 2004; Nieto et al., 2008), English-speaking children (Halperin, Healey, Zeitchik, Ludman, & Weinstein, 1989), French-speaking children (Sauzéon et al., 2004), and Hebrew-speaking children (Kavé, 2006; Koren et al., 2005); nevertheless, it is important to point out that the selected semantic categories vary among studies.

In the PVF, although different letters are used depending on the language of origin, the number of generated words is consistent with different studies realized in different countries and languages, with an average of 5 to 6 words per letter in 8–9-year-old children and of 7 to 8 words in 10–11-year-old children (Halperin et al., 1989; Kavé, 2006; Matute et al., 2004; Nieto et al., 2008; Sauzéon et al., 2004). Martins et al. (2007) also asserted an average of 7–8 words per letter in Portuguese-speaking children aged 11. Relating to the letters used to measure the phonological fluency of Spanish-speaking children, previous studies have used the letter M (Matute et al., 2004), the letters F, A, and M (Nieto et al., 2008), and the FAS version of the test (Ardila & Rosselli, 1994; Pineda et al., 1998, 1999). In this study the selection of the FAS version was based on the following aspects: (a) the PVF for these letters has been normalized in Spanish-speaking children from 5 to 12 years old (Ardila & Rosselli, 1994) and (b) previous studies carried out with Spanish-speaking child samples have demonstrated that this version enables researchers to discriminate between groups with different infantile disorders. For example, it has been found that children with ADHD obtain significantly low performance in the phonological task in opposition to control children (Pineda et al., 1998, 1999). Thus the present study used this FAS version to contribute to normative values not only for the total score obtained, but also in the employment of strategies and performance according to time. It is important to state that the total FAS score obtained in our results was similar to the ones obtained by Nieto et al. (2008) in reference to the letters F, A, and M (FAM). Therefore we consider that the evaluation of the PVF in Spanish-speaking children might be carried out with letters FAS and well as with letters FAM.

We have also found certain similarity to other studies carried out with Spanish-speaking children (Nieto et al., 2008) and with Hebrew-speaking children (Koren et al., 2005) in relation to the number of clusters and switching strategies used, with an increase in the employment of the former strategies depending on age. Taken together, similarities found among several studies performed in different countries and with diverse languages maintain the cross-cultural validity of this scoring method of VF tasks.

Our results are congruent with developmental studies that show an increased performance in relation to the total score obtained in VF tasks (Anderson et al., 2001; Klenberg et al., 2001; Matute et al., 2004; Nieto et al., 2008; Riva et al., 2000) and the use of clustering and switching strategies (Kavé et al., 2008; Nieto et al., 2008; Sauzéon et al., 2004) over the years. This increase seems to be related to structural changes associated with brain maturation. It has been suggested that while white matter density follows a linear course from childhood to adulthood (Giedd et al., 1999; Paus et al., 1999), gray matter density in the frontal lobe decreases during post-adolescence (Giedd et al., 1999; Gogtay et al., 2004). Moreover, there would be changes in brain myelinization processes (Sowell, Thompson, Tessner, & Toga, 2001; Sowell et al., 2004), synaptic density (Huttenlocher & Dabholkar, 1997), interhemispheric fiber systems (Thompson et al., 2000), and metabolic processes (Chugani, 1999). In this regard, an increase in executive tasks resulting from maturation of brain structures supporting these functions can be expected. In addition, since these structural and metabolic changes correspond with the emergence of several cognitive functions, differences found in each group in terms of performance in the test and use of organizational strategies are also likely to rely on an increase in complexity of cognitive strategies occurring with age. According to the cognitive complexity and control (CCC) theory (Zelazo & Frye, 1997, 1998), age-related changes in executive functions would be attributed to changes in the maximum complexity of rules children can represent and use when solving problems. Therefore it is feasible to think that with age, in addition to changes in brain maturation, children would use more complex cognitive strategies allowing them a more effective systematic internal search due to higher problem-solving ability, memory, and cognitive flexibility.

Finally, in relation to associations among cognitive variables, the results point to a relationship between verbal fluency and other executive functions. Consistent with the statements of Ruff et al. (1997), these data suggest that verbal fluency taps other cognitive processes such as attention, cognitive flexibility, search and initiation, verbal retrieval, and recall. Therefore it can be assumed that proper task performance would depend on other cognitive processes such as attention, access to semantic memory, and executive functioning. These results offer strong support for the validity of both phonological and semantic fluency as executive measures, and sustain the findings of Henry and Crawford (2004). Likewise, strategies employed in fluency tasks were associated with higher cognitive function, indicating that clustering and switching among categories imply underlying cognitive processes such as attentional and inhibitory control, working memory, immediate and delayed verbal memory, and cognitive flexibility. However, low positive correlations were found between phonological cluster size and these cognitive functions, and there were not significantly correlations between executive and verbal retrieval processes and semantic cluster size. Therefore it is believed that cluster size, primarily on the SVF, would depend on other specific cognitive functions, such as lexico-semantic knowledge and semantic organization. In contrast, the ability to initiate clustering and to switch between clusters would involve higher-order cognitive processes such as executive functions and attention. This suggests that clusters and switches are more sensitive indexes of executive functioning than cluster size in school-aged children.

The present study reveals some limitations that should be noted. First, only children of ages ranging from 8 to 11 years were included. Since the development of VF tasks exceeds the estimated ages it is not feasible to document precisely the age at which adult performance is reached in this method of analysis for tasks of verbal fluency. Nevertheless, previous studies (Hurks et al., 2006; Koren et al., 2005; Nieto et al., 2008) have used an age range similar to that of our study and this strengthens the generalization of the results for the evaluated ages. A second limitation of this study is the use of a cross-sectional design to document the development achieved as regards the examined ages. However, although longitudinal studies offer a more valuable design to study development, it has been indicated that cross-sectional studies offer the opportunity to study and compare wide domains of development (Korkman, 2001). In addition, several studies have used this design to study VF development in children (Koren et al., 2005; Matute et al., 2004; Nieto et al., 2008; Sauzéon et al., 2004).

In summary, it is possible to conclude that: (a) semantic fluency tasks would be easier than phonological ones, (b) the number of words for both tasks decreases significantly after 15 seconds in the period of 1 minute, (c) clustering and switching strategies would optimize the search of words in the internal lexicon since they predict the total score obtained in both VF tasks—while number of clusters most strongly accounts for variations in the number of words generated in the SVF, the total words produced in the PVF would be primarily predicted by the number of switches—(d) performance in VF tasks and the use of cognitive strategies are positively associated with age, and (e) VF tasks and number of clusters and switching strategies appear significantly related to the executive functioning. These scoring methods of VF tasks have clinical and theoretical implications as they offer additional insight into cognitive processes and word retrieval strategies in children. Since performance over time can provide a measure of automatic versus controlled processes, and clustering and switching components of VF appear to reflect efficient retrieval strategies and are associated with cognitive executive processes, these analyses could be particularly useful in clinical assessment and differential diagnosis of executive dysfunction in developmental disorders.

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