Received: 11 September 2022 | Accepted: 9 April 2023

DOI: 10.1111/1460-6984.12891

International Journal of Language & Communication Disorders

RESEARCH REPORT

Phonological and semantic verbal fluency test: Scoring criteria and normative data for clustering and switching strategies for Colombian children and adolescents

María Nazaret Álvarez Medina[1] | **Esperanza Vergara Moragues**[2,3] | **Juan Carlos Arango-Lasprilla**[4] | **Juan Carlos Restrepo Botero**[5] | **José Amilkar Calderón Chaguala**[6] | **Diego Rivera**[7,8] | **Laiene Olabarrieta-Landa**[7,8]

[1]Departamento de Psicobiología y Metodología en Ciencias del Comportamiento, Universidad, Complutense de Madrid, Madrid, Spain

[2]Department of Psychology, University of Cadiz (UCA), Cadiz, Spain

[3]Instituto de Investigación e Innovación Biomédica de Cádiz (INiBICA), Cadiz, Spain

[4]Virginia Commonwealth University, Richmond, VA, USA

[5]Tecnológico de Antioquia—Institución Universitaria, Medellín, Colombia

[6]Facultad de Psicología, Universidad Antonio Nariño, Ibagué, Colombia

[7]Departamento de Ciencias de la Salud, Universidad Pública de Navarra, Pamplona, Navarra, Spain

[8]Instituto de Investigación Sanitaria de Navarra (IdiSNA), Pamplona, Navarra, Spain

Correspondence
Diego Rivera, Universidad Publica de Navarra, Campus de Arrosadia, Pamplona, Navarra, Spain; Instituto de Investigacion Sanitaria de Navarra (IdiSNA), Pamplona, Navarra, Spain.
Email: diego.rivera@unavarra.es

Laiene Olabarrieta-Landa, Universidad Publica de Navarra, Campus de Arrosadia, Pamplona, Navarra, Spain; Instituto de Investigacion Sanitaria de Navarra (IdiSNA), Pamplona, Navarra, Spain.
Email: laiene.olabarrieta@unavarra.es

Funding information
This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Abstract

Background: Verbal fluency tests (VFT) are highly sensitive to cognitive deficits. Usually, the score on VFT is based on the number of correct words produced, yet it alone gives little information regarding underlying test performance. The implementation of different strategies (cluster and switching) to perform efficiently during the tasks provide more valuable information. However, normative data for clustering and switching strategies are scarce. Moreover, scoring criteria adapted to Colombian Spanish are missing.

Aims: (1) To describe the Colombian adaptation of the scoring system guidelines for clustering and switching strategies in VFT; (2) to determine its reliability; and (3) to provide normative data for Colombian children and adolescents aged 6–17 years.

Methods & Procedures: A total of 691 children and adolescents from Colombia completed phonological (/f/, /a/, /s/, /m/, /r/ and /p/) and semantic (animals and fruits) VFT, and five scores were calculated: total score (TS), number of clusters (NC), cluster size (CS), mean cluster size (MCS) and number of switches (NS). The intraclass correlation coefficient was used for interrater reliability. Hierarchical multiple regressions were conducted to investigate which strategies were associated with VFT TS. Multiple regressions were conducted for each strategy, including as predictors age, age^2, sex, mean parents' education (MPE), MPE^2 and type of school, to generate normative data.

Outcomes & Results: Reliability indexes were excellent. Age was associated with VFT TS, but weakly compared with strategies. For both VFT TS, NS was the strongest variable, followed by CS and NC. Regarding norms, age was the strongest predictor for all measures, while age^2 was relevant for NC (/f/ phoneme) and NS (/m/ phoneme). Participants with higher MPE obtained more NC, and NS, and larger CS in several phonemes and categories. Children and adolescents from private school generated more NC, NS and larger CS in /s/ phoneme.

Conclusions & Implications: This study provides new scoring guidelines and normative data for clustering and switching strategies for Colombian children and adolescents between 6 and 17 years old. Clinical neuropsychologists should include these measures as part of their everyday practice.

KEYWORDS
children, clustering, phonological fluency, semantic fluency, switching

WHAT THIS PAPER ADDS

What is already known on the subject

- VFT are widely used within the paediatric population due to its sensitivity to brain injury. Its score is based on the number of correct words produced; however, TS alone gives little information regarding underlying test performance. Several normative data for VFT TS in the paediatric population exist, but normative data for clustering and switching strategies are scarce.

What this paper adds to existing knowledge

- The present study is the first to describe the Colombian adaptation of the scoring guidelines for clustering and switching strategies, and provided normative data for these strategies for children and adolescents between 6 and 17 years old.

What are the potential or actual clinical implications of this work?

- Knowing VFT's performance, including strategy development and use in healthy children and adolescents, may be useful for clinical settings. We encourage clinicians to include not only TS, but also a careful analysis of strategies that may be more informative of the underlying cognitive processes failure than TS.

INTRODUCTION

In paediatric neuropsychological assessment, verbal fluency tests (VFT) are commonly used due to their high sensitivity to detect cognitive deficits in individuals with acquired neurological disorders and neurodevelopmental conditions (Henry & Crawford, 2004), such as attention deficit hyperactive disorder (Takács et al., 2014), autism spectrum disorders (Begeer et al., 2014) or dyslexia (Mielnik et al., 2015). These neuropsychological tests require the ability to organize the words according to specific rules in a given time (generally 60 s). Several VFT exist, but semantic and phonological VFT are widely used within the paediatric population. Animals and fruits represent the most common categories used during semantic verbal fluency with children and adolescents (Martins-Oliveira et al., 2016; Olabarrieta-Landa et al., 2017a; Van der Elst et al., 2011). For phonological verbal fluency, cultural and linguistic aspects are taken into consideration to determine the letter to use. For instance, in Spanish the letters/phonemes M, R and P have been proposed as the most appropriate (Artiola et al., 1999; Olabarrieta-Landa et al., 2019), but the set F, A and S are usually selected to use because its broad use in the literature (Tallberg et al., 2011).

VFT can be used to assess long-term verbal semantic memory, phonological awareness, lexical–semantic access and executive function (Delis et al., 2001; Fitzpatrick et al., 2013). However, despite the similarity between tasks, the cognitive processes and brain substrates that underlie each one seem to be different. During semantic VFT, strategic organization, response inhibition and cognitive flexibility are needed (Azuma, 2004; Sauzeon et al., 2004), as well as memory and semantic knowledge (Arán-Filippetti & Allegri, 2011; Henry & Crawdford, 2004). During semantic VFT, words evocation is based mainly in generating semantic associations as well as words' meaning. However, phonological verbal fluency demands more executive control since it implies a selection effort to retrieve words according to the initial letter/phoneme, instead of lexicon–semantic networks (Delgado-Álvarez et al., 2021). Previous studies have suggested that brain networks implicated also differ depending on VFT task, at least partially; while phonological VFT have been related to higher frontal lobe implication, semantic VFT related to higher temporal lobe, although this is often debated (Kircher et al., 2011). It is more likely that VFT rely on several brain areas, mainly from frontal and temporal lobes, that require coordinated activation (Wagner et al., 2014).

Usually, the score on VFT is based on the number of correct words produced; however, total score (TS) alone gives little information regarding underlying test performance (Becker et al., 2019). Thus, Troyer et al. (1997, 2000) suggested the use of qualitative assessment, as VFT require the implementation of different strategies to retrieve words to perform efficiently during the tasks. Clustering consists of grouping words within a subcategory. It is an automatic action, less demanding for working memory, because it requires the recovery of words belonging to a certain category, that is, represented within long-term memory (Azuma, 2004; Martins et al., 2007; Riva et al., 2000). It is proposed to rely primarily on temporal lobe activation (Troyer et al., 1997). Switching is the ability to jump between clusters and it has been related to the frontal lobe activation (Abwender et al., 2001; Wagner et al., 2014). Words beginning with a given letter/phoneme are unlikely to be represented in the same way as semantics, and therefore the strategy to be used is different. Producing words beginning with a specific letter demands the exploration of more subdivision categories, cognitive flexibility and set switching (Martins et al., 2007; Riva et al., 2000), which involve the increasing use of cognitive skills, especially executive functions (Rende et al., 2002; Troyer, 2000). Searching strategies require more attention resources, higher demand for working memory compared with clustering, which implies an activation automatic process. Bearing in mind the different cognitive processes and the brain substrates involved in both strategies, it is easy to understand why semantic verbal fluency seems to be easier than phonological fluency, not only for children but also for adults.

According to the literature, the most important variable associated with children and adolescents' verbal fluency performance is age (i.e., Olabarrieta-Landa et al., 2017b; Van der Elst et al., 2011), showing older children and adolescents perform better on VFT. This is not surprising since verbal fluency requires executive function and frontal lobe maturation, and children do not yet have fully achieved these milestones (Anderson, 2002; Anderson et al., 2001). Besides age, other variables have been reported such as parents' education and sex. It seems that children and adolescents whose parents had higher educational level perform better in VFT compared with those with lower educational level (i.e., Olabarrieta-Landa et al., 2017b; Rivera et al., 2021; Van der Els et al., 2011). Sex has been inconsistently associated with VFT; however, most studies have reported no sex differences (i.e., Malloy-Diniz et al., 2007; Ruffieux et al., 2009; Tallberg et al., 2011; Van der Elst et al., 2011) or when differences arise, its impact was very small compared with age or parents' education (Olabarrieta-Landa et al., 2017b; Rivera et al., 2021). Thus, both age and parents' education level are extremely important variables to consider when assessing verbal fluency in this population.

Due to its broad use in clinical and research settings, the number of studies focused on providing normative data for VFT in the paediatric population has increased during recent years (i.e., García et al., 2012; Martins-Oliveira et al., 2016; Olabarrieta-Landa et al., 2017b; Rivera et al., 2021; Van der Elst et al., 2011). However, most of these studies have focused on TS, and more normative data for clustering and switching strategies during VFT are needed, especially for Latin American Spanish-speaking countries. Norms for clustering and switching strategies for children and adolescents population can be found for Australia (Chami et al., 2018), Brazil (Becker et al., 2019;

Gonçalves et al., 2017), France (Sauzéon et al., 2004), India (John & Rajashekhar, 2014; John et al., 2016, 2018), Israel (Kavé et al., 2008; Koren et al., 2005), the Netherlands (Hurks et al., 2010; Resch et al., 2014) and Sweden (Tallberg et al., 2011). Finally, for Spanish-speaking children, Arán-Filippetti and Allegri (2011) provided norms for Argentinian children between 8 and 11 years of age using 120 participants, while Nieto et al. (2008) it was for Spaniard children between 6 and 11 years old using 79 participants. More recently, Sánchez-López et al. (2021) explored clustering and switching strategies in a group of 51 children between 8 and 11 years old from Spain.

Troyer et al. (1997, 2000) established the first criteria for scoring clustering and switching strategies, and most research followed these rules (i.e., Arán-Filippetti & Allegri, 2011). However, these criteria are adapted to the Canadian English context. Villodre et al. (2006) established guidelines for Spaniard Spanish context for three categories (animals, fruits and clothes) and three letters (F, A and S), but they provided normative data for the adult population. Even though Spanish is also the main language for most Latin American countries, its context is totally different from Spain, so it is difficult to apply Villodre's criteria without adaptation, especially for animals and fruits categories. Therefore, the objectives of this study were: (1) to describe the Colombian adaptation of the new scoring system guidelines for clustering and switching strategies in phonological and semantic VFT; (2) to determine its reliability; and (3) to provide normative data for clustering and switching strategies in Colombian children and adolescents aged 6–17 years.

METHODS

Participants

A total of 691 children and adolescents aged 6–17 years from four Colombian cities participated in the study. All participants were involved in a larger study aimed to generate normative data for neuropsychological tests for Spanish-speaking children and adolescents (Rivera et al., 2017). The inclusion criteria for this study were: (1) to be between 6 and 17 years of age; (2) to have Spanish as the primary language; (3) to have an IQ ≥ 80 on the Non-verbal Intelligence Test (TONI-2; Brown et al., 2009); and (4) to have a score of < 19 on the Children's Depression Inventory (CDI; Kovacs, 1992). Participants with a history of neurologic/psychiatric disorders reported by participant's parents or guardians were excluded. A total of 24 participants were excluded due to incomplete sociodemographic information. The final total sample consisted of 667 children and adolescents (Bogota [n = 156], Cali [n = 141], Ibague [n = 190] and Medellin [n = 180]). The majority of participants were girls (54.4%); the mean age was 11.6 (SD = 3.3); and mean parents' education (MPE) was 12.2 (SD = 3.6). See Table 1 for more details.

TABLE 1 Sociodemographic characteristics of the sample

Age	n_i	Age Mean (SD)	Sex Girls n_i (%)	Boys n_i (%)	MPE Mean (SD)
6.0	53	6.3 (0.2)	29 (54.7%)	24 (45.3%)	12.5 (3.6)
7.0	58	7.3 (0.3)	28 (48.3%)	30 (51.7%)	12.4 (3.3)
8.0	49	8.3 (0.2)	27 (55.1%)	22 (44.9%)	12.2 (3.2)
9.0	58	9.2 (0.2)	31 (53.4%)	27 (46.6%)	12.4 (3.7)
10.0	58	10.3 (0.3)	29 (50.0%)	29 (50.0%)	11.7 (3.0)
11.0	70	11.2 (0.3)	41 (58.6%)	29 (41.4%)	11.8 (3.4)
12.0	70	12.3 (0.2)	38 (54.3%)	32 (45.7%)	11.4 (3.7)
13.0	53	13.2 (0.3)	31 (58.5%)	22 (41.5%)	11.5 (3.8)
14.0	58	14.2 (0.2)	33 (56.9%)	25 (43.1%)	13.2 (3.2)
15.0	54	15.2 (0.2)	30 (55.6%)	24 (44.4%)	12.8 (4.3)
16.0	46	16.2 (0.3)	26 (56.5%)	20 (43.5%)	13.3 (3.4)
17.0	40	17.2 (0.2)	19 (47.5%)	21 (52.5%)	11.4 (4.0)

Note: MPE, mean parents' education.

Instruments

Participants were asked to provide as many words as possible within 60 s in each of six phonemes (/f/, /a/, /s/, /m/, /r/ and /p/) and two categories (animals and fruits). For each phoneme/category, the following scores were obtained.

Total score (TS) corresponds to the total number of correct words produced in each phoneme and category following Olabarrieta-Landa et al.'s (2017a) scoring guidelines. Briefly, for phonological VFT, spelling rules were not considering because phoneme was asked, and proper names, intrusions, repetitions, augmentative or diminutive, or grammatical variations of gender, number, person and tense were not accepted. Derived words were accepted if they were used to form new words with different meaning. For semantic VFT, superordinate words (e.g., fish) were accepted as long as the participant did not include words or examples that belong to the same superordinate category (e.g., shark, sardine). Proper names, intrusions, repetitions, augmentative or diminutive or grammatical variation of number were not accepted. For animals' category, gender variation was accepted (e.g., cow, bull), as well as words that represent the same animal in different developmental stages (e.g., calf–cow). Also, extinct and magical/mythological animals were accepted.

Number of clusters (NC) was defined as the total NC produced in 60 s, considering a cluster as the successive generation of at least two related words. Thus, single words were not considered a cluster since, as Koren et al. (2005) suggested, single words may rather indicate participants' difficulties to retrieve words from a particular category, hence, they are unable to use an associative strategy.

Cluster configuration criteria were adapted to the Colombian context. Researchers discussed and established the following criteria based on Troyer et al.'s (1997, 2000) and Villodre et al.'s (2006) scoring guidelines, as well as a subsample participants retrieval pattern. For a phonological cluster, there was no need to implement many changes to the original criteria; thus, Troyer et al.'s (1997) rules were followed: words starting with the same two letters or phoneme, words that rhyme, words that differ only by a vowel sound and homonymous words. Note that the only change was to consider not only words starting with the same two letters, but also two phonemes as a cluster. See Appendix A1 in the additional supporting information for examples.

However, for semantic cluster, greater modifications were needed. The original cluster criteria (Troyer et al., 1997) were living environment (e.g., Africa, Australia, Arctic/Far North), human use (e.g., beasts of burden, fur, pets) and zoological categories (e.g., bird, bovine, canine, deer). As many of these categories were too broad and did not match with Spanish-speaking context, Villodre et al. (2006) adapted this proposal to a Spaniard adult sample. These authors used the following categories: pets or farm animals, Spanish mountain range animals, tropical or jungle animals, reptiles, animals that fly, water-living animals, insect and pairs of words that have a strong relationship because they are part of popular culture or are included in fables or stories. As this classification was focused in Spanish context, we further adapted it to the Colombian context (see Appendix A2 in the additional supporting information). Regarding the fruits category, Villodre et al. (2006) established the following criteria: winter fruits, summer/spring fruits, tropical fruits and nuts. However, this classification is not appropriated for Colombia because there is no division of seasons, and multiple and very diverse types of fruit exist. Thus, we proposed the following classification: sweet, acid, semi-acid fruits and nuts. Following Troyer's (2000) instructions, when an item belongs to two categories, the overlapping item was assigned to both categories. For example, if the sequence is 'cat, cheetah, lion, elephant, crocodile', lion would be part of two clusters, the first cluster 'feline' (cat–cheetah–lion) and the second cluster 'animals from Africa' (lion–elephant–crocodile). Also, if a cluster involves smaller clusters within, the larger category was used. For example, in the sequence 'cat, dog, cow, bull, chicken, horse', cat and dog are part of 'pets' cluster, but this cluster is within a larger cluster 'farm animals' (see Appendix A3 in the additional supporting information).

Finally, following Troyer et al.'s (1997) instructions, *number of switches* (NS) corresponds to the total number of transitions, including errors and perseverations, from a single word to a cluster, from a cluster to another cluster, from a cluster to a single word, or from a single word to a single one. *Cluster size* (CS) is calculated summing the words in each cluster (counting begins with the second word); however, *mean cluster size* (MCS) is derived by dividing CS for the total of number clusters (Troyer et al., 1997).

Procedure

The data for this study come from an international project whose main aim was to generate normative data for a neuropsychological battery for children and adolescents between 6 and 17 years from 10 Latin American countries and Spain (Rivera & Arango-Lasprilla, 2017). For this study, only the Colombian (Rivera et al., 2017) subsample was used. The study protocol was approved by the Research Ethics Committee of different participant institutions from Colombia (Universidad Los Libertadores, Universidad San Buenaventura and Universidad Simon Bolivar).

The neuropsychological battery was composed of 10 tests, including VFT, and was administered in a single session and lasted approximately 120 min. During VFT, participants' productions were transcribed in the same order in which participants produced, including repetitions and errors, and the watch was not stopped until 60 s. All participants completed the task in the same order: first, the phonological task, in the following order: /f/, /a/, /s/, /m/, /r/ and /p/ phonemes, and then the semantic task, beginning with animals' category and then fruits. Before test administration, parents or guardians and children of 12 years and older signed the informed consent, while children under 12 years of age signed the assent. All participants were volunteers who did not receive financial compensation for participation. Data collection started in January 2016 and finished in January 2017. For further information about the procedure, see Rivera et al. (2017).

Statistical analyses

Scoring reliability

A subsample (n = 137) was used to estimate interrater reliability. Researchers M.N.A., E.V.M. and L.O.L. independently scored the words generated by each VFT. Raters estimated NC, NS, CS and MCS measures using the same scoring guidelines. If a consensus was not reached, the scoring guidelines were reviewed by the entire team, and specified or modified the instructions to reduce inconsistency in scoring interpretation. Intraclass correlation coefficient (ICC) was used to estimate interrater reliability to each score. To estimate the ICC two-way mixed effects model, the mean of *k* raters' type and absolute agreement definition was used (Koo & Li, 2016).

Effects of sociodemographic variables, and clustering and switching strategies on TS

Two hierarchical multiple regressions were run to investigate the extent to which clustering and switching strategies (NC, CS, MCS and NS) were associated with each of phonemes (/f/, /a/, /s/, /m/, /r/ and /p/), and category (animals and fruits) TS after controlling for demographics characteristics (age, MPE and sex). This had the aim to demonstrate the impact of strategies on VFT TS, since we hypothesize that those children and adolescents who use more strategies will obtain a higher TS. In each regression model, age, MPE and sex were entered as variables in the first step, and each TS was entered as the dependent variable. An alpha-level of ≤ 0.05 was used for the analyses.

Normative data

Multiple regression analyses were conducted for each clustering and switching strategy following Rivera et al. (2021) methodology. The full regression models were included as predictors: age, quadratic age, sex, MPE, quadratic MPE, type of school and two-way interactions between the fixed effects. MPE was calculated using the mean years of education for both parents/guardians, if possible. If a child had a single parent/guardian, the MPE was calculated using his or her years of education. Age was centred [= calendar age – mean age in the sample ($\bar{X} = 11.6$)] and MPE [= MPE – mean MPE in the sample ($\bar{X} = 12.2$)] before computing the quadratic age and MPE term to avoid multicollinearity. Sex was coded as boy = 1 and girl = 0, while type of school as public school = 1 and private school = 0. A forward stepwise procedure was used for model-building, where predictors were not removed as long as they were included in a higher order term in the model. An alpha-level of ≤ 0.005 was used in regression analyses to avoid Type I errors due to multiple testing (Van der Elst et al., 2011).

For each final regression model, the following assumptions were evaluated (Kutner et al., 2005): (1) multicollinearity, looking at variance inflation factor (VIF), (2) the existence of influential values, using Cook's distances, (3) homoscedasticity, evaluated applying the Breusch–Pagan test and (4) normality of the standardized residuals (z_i), evaluated by the Kolmogorov–Smirnov test.

Using beta values of each final regression model, four steps were followed (Rivera et al., 2021) to estimate *z*-scores (z_i) and percentile (Pc_i) adjusted to demographical variables: (1) the predict score ($\hat{Y}_i$) was computed based on the fixed effect parameter estimated of the established final regression model; (2) to estimate residual value (e_i) the following formula: $e_i = Y_i - \hat{Y}_i$ was used; (3) residuals should be standardized using the residual standard deviation (SD_e) of the regression model: $z_i = e_i / SD_e$; and (4) to convert z_i to Pc_i, the standard normal cumulative distribution function was used if the model assumption of normality of the standardized residuals was met in the normative sample. If the standardized residuals were not normally distributed in the normative sample, the empirical cumulative distribution function of the standardized residuals was used. This four-step process was applied to each score (NC, CS, MCS and NS) separately by each /f/, /a/, /s/, /m/, /r/ and /p/ phonemes, animals and fruits categories. All analyses were performed using *R* version 4.2.0 (R Development Core Team, 2022), except for ICC which was performed using SPSS.

RESULTS

Scoring reliability

ICC values showed excellent reliability because the majority scores were above 0.90 ($IC_{95\%} = 0.872–0.928$, $p < 0.001$). Animals' NC (0.852; $IC_{95\%} = 0.785–0.897$, $p < 0.001$), animals' CS (0.852; $IC_{95\%} = 0.802–0.890$; $p < 0.001$) and MCS of R phoneme (0.851; $IC_{95\%} = 0.802–0.890$; $p < 0.001$) showed good reliability. Finally, animals' MCS (0.608; $IC_{95\%} = 0.480–0.709$, $p < 0.001$) showed a moderate reliability (Koo & Li, 2016). For more details about ICC values for each score, see Table 2.

Effects of sociodemographic variables, and clustering and switching strategies on TS

Means and SD for the qualitative strategies are presented in Table 3.

In the first hierarchical multiple regression model for phonological fluency TS, the sociodemographic characteristics were entered into the first step. This first model was significant ($F_{3,663} = 163.7$, $p = 0.001$) and explained 42.6% of the variance. The second model including the clustering and switching strategies was also significant ($F_{7,659} = 2327$, $p < 0.001$) and explained 96.1% of the variance. When the phonological fluency was regressed onto strategies, the

TABLE 2 Intraclass correlation coefficients (ICC) and 95% confidence interval

	Intraclass correlation	95% confidence interval		*F*-test with true value 0			
		Lower bound	Upper bound	Value	df1	df2	Sig.
Number of cluster F	0.966	0.954	0.975	30.772	139	278	< 0.001
Number of cluster A	0.954	0.939	0.966	22.405	139	278	< 0.001
Number of cluster S	0.961	0.949	0.971	26.013	139	278	< 0.001
Number of cluster M	0.941	0.922	0.956	17.533	139	278	< 0.001
Number of cluster R	0.946	0.928	0.960	19.028	139	278	< 0.001
Number of cluster P	0.967	0.955	0.976	32.072	139	278	< 0.001
Number of cluster animals	0.852	0.785	0.897	7.721	139	278	< 0.001
Number of cluster fruits	0.930	0.907	0.948	14.212	139	278	< 0.001
Cluster size F	0.979	0.972	0.985	49.971	139	278	< 0.001
Cluster size A	0.970	0.960	0.978	34.313	139	278	< 0.001
Cluster size S	0.985	0.980	0.989	68.314	139	278	< 0.001
Cluster size M	0.970	0.960	0.977	33.329	139	278	< 0.001
Cluster size R	0.744	0.661	0.810	3.924	139	278	< 0.001
Cluster size P	0.979	0.972	0.984	47.850	139	278	< 0.001
Cluster size animals	0.852	0.802	0.890	6.944	139	278	< 0.001
Cluster size fruits	0.945	0.924	0.960	19.640	139	278	< 0.001
Number of switches F	0.984	0.978	0.988	60.373	138	276	< 0.001
Number of switches A	0.979	0.972	0.984	47.616	137	274	< 0.001
Number of switches S	0.972	0.963	0.980	36.609	137	274	< 0.001
Number of switches M	0.963	0.951	0.973	27.552	137	274	< 0.001
Number of switches R	0.992	0.990	0.994	128.897	137	274	< 0.001
Number of switches P	0.988	0.985	0.991	87.228	137	274	< 0.001
Number of switches animals	0.903	0.872	0.928	10.380	137	274	< 0.001
Number of switches fruits	0.960	0.945	0.971	26.412	137	274	< 0.001
Mean cluster size F	0.978	0.971	0.984	46.163	136	272	< 0.001
Mean cluster size A	0.958	0.945	0.969	230.980	136	272	< 0.001
Mean cluster size S	0.988	0.985	0.991	87.804	136	272	< 0.001
Mean cluster size M	0.943	0.925	0.958	17.571	136	272	< 0.001
Mean cluster size R	0.851	0.802	0.890	6.694	136	272	< 0.001
Mean cluster size P	0.971	0.961	0.978	34.262	136	272	< 0.001
Mean cluster size animals	0.608	0.480	0.709	2.576	136	272	< 0.001
Mean cluster size fruits	0.895	0.859	0.923	10.022	136	272	< 0.001

amount of variance explained increased by a significant $\Delta R^2 = 0.535$, $\Delta F_{4,659} = 2269.4$, $p < 0.001$. Age (*beta* = 0.008, $p < 0.001$) was significantly related to phonological fluency, such that older participants produced more words in phonological VFT. MPE was, at the first step, significantly related to phonological fluency TS (beta = 0.12, $p < 0.001$), but when strategies were introduced at the second step, it was no longer associated with it. Additionally, NC (*beta* = 0.10, $p < 0.001$), CS (*beta* = 0.28, $p < 0.001$) and NS (*beta* = 0.69, $p < 0.001$) were significantly associated with phonological fluency TS, so that those children and adolescents who generated more and larger clusters, and produced more switches obtained higher TS. However, sex and MCS were not related to phonological verbal fluency TS (*p*'s > 0.05) (Table 4).

In the second hierarchical multiple regression model for semantic fluency TS, the sociodemographic characteristics were entered into the first step, and this model was significant ($F_{3,663} = 167.7$, $p = 0.001$) and explained 43.1% of the variance. The second model including the clustering and switching strategies was also significant ($F_{7,659} = 1381$, $p < 0.001$) and explained 93.6% of the variance. When the semantic fluency was regressed onto strategies, the amount of variance explained increased by a significant $\Delta R^2 = 0.505$, $\Delta F_{4,659} = 1303.3$, $p < 0.001$. Age (*beta* = 0.004, $p < 0.001$) was significantly related to semantic TS, such

TABLE 3 Means and standard deviation (SD) for the qualitative strategies

Score	NC		CS		NS		MCS	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
F	1.14	1.04	1.60	1.70	4.38	2.74	1.02	1.02
A	1.31	1.07	1.80	1.59	5.16	2.97	1.07	0.86
S	1.45	1.05	2.30	1.88	4.30	2.81	1.41	1.20
M	1.55	1.05	2.65	1.95	4.59	3.26	1.63	1.27
R	1.44	1.04	2.16	1.76	4.19	2.81	1.30	1.01
P	1.61	1.17	2.45	1.99	5.54	3.41	1.35	1.07
Animals	3.43	1.61	5.93	3.10	7.91	3.49	1.80	1.08
Fruits	2.36	1.31	3.60	1.99	6.55	2.79	1.59	0.92

Note: CS, cluster size; MCS, mean cluster size; NC, number of clusters; NS, number of switches.

that older participants produced more words in semantic VFT. MPE was, at the first step, significantly related to semantic fluency TS (*beta* = 0.18, $p < 0.001$), but when strategies were introduced at the second step, there was no longer an association. Additionally, CS (*beta* = 0.51, $p < 0.001$) and NS (*beta* = 0.61, $p < 0.001$) were significantly associated with semantic fluency TS, so that those children and adolescents who generated larger CS and produced more switches obtained higher TS. However, sex, NC and MCS were not related to semantic verbal fluency TS (p's > 0.05).

Normative data

All regression models met multicollinearity and the absence of influential values (according to Cook's distances) assumptions. The lack of homoscedasticity was corrected by estimating the residual SD by quartiles of the predicted scores to each regression model. As 18 regression models did not follow normal distribution, the empirical cumulative distribution function of the standardized residuals was used.

In all phonemes used during phonological verbal fluency, CS, NC and NS scores increased linearly with age, except for /p/ phoneme, so that older children and adolescents got longer CS, and produced more NC and NS in each phoneme. Moreover, NC in /f/ phoneme and NS in /m/ phoneme were also affected by quadratic age. Those children and adolescents whose parents had more years of education achieved longer CS in /a/ and /r/ phonemes, formed more NC in /a/ phoneme and more NS in /a/ and /m/ phonemes. Type of school was also significantly associated with CS, NC and NS in /s/ phoneme, so that those participants attending to a public school got longer CS, and made more NC and NS in this phoneme. In /p/ phoneme, a significant Age by MPE interaction was found, such that MPE influence became greater as children grown.

Regarding semantic verbal fluency, animals and fruits' CS, NC and NS scores increased linearly as a function of age, so that older children and adolescents achieved longer CS, and produced more NC and NS. MPE was also associated with animals and fruits' CS, and NC, and fruits' NS, so that those children and adolescents whose parents had more years of education reported longer CS and made more NC in these categories, and more NS in fruits' category (Table 5 and Figure 1).

Sex and MPE^2 were not related to any score. For MCS, the models were not significant ($R^2 \leq 0.022$), so, to generate normative data, mean and SD were used.

In order to facilitate the calculation of normative data, the authors created a calculator in which the professional must include the following information: phoneme or category used, age, MPE, type of school and raw scores, to calculate the z score and percentile. This tool is freely available for all users and can be downloaded at https://neuropsychologylearning.com/datos-normativos-archivos-descargables/

DISCUSSION

The present study described the adaptation of scoring guidelines for clustering and switching strategies in phonological and semantic VFT, assessed its interrater reliability, and provided normative data for children and adolescents between 6 and 17 years old. As Troyer et al.'s (1997) study was conducted in Canada, their original proposal required modifications to the Colombian context, especially the semantic task. Although Villodre et al. (2006) adapted the proposal to the Spaniard adult population, some of their animals' categories did not match with the Colombian context (i.e., Spanish mountain range animals, pairs of words with strong relationship due to fables or stories). The same happened with their fruits categories because in Colombia there is no season division and multiple and very diverse types of fruits exist. The results of the proposed new scoring guidelines reliability were excellent for the vast majority of scores, demonstrating that the adaptation of scoring cluster and switching strategies for Colombian children and adolescents is consistent, and this may be used in other Latin American countries with similar characteristics. Becker and Salles (2016) also proposed a new method for scoring clustering and switching adapted to the Brazilian context, and found good reliability.

The third aim of this study was to generate normative data for clustering and switching strategies for Colombian children and adolescents. Before computing normative data, hierarchical linear models were run to show the

International Journal of Language & Communication Disorders

TABLE 4 Hierarchical regression for total score (TS) in each verbal fluency test (VFT)

Variables		Standardized beta 95% CI [LL, UL]	R^2 95% CI [LL, UL]	ΔR^2
Phonological fluency				
Step 1	Age	0.64** [0.58, 0.70]	0.426** [0.37, 0.47]	0.426
	Sex	−0.01 [−0.07, 0.05]		
	Mean parents' education	0.12** [0.06, 0.18]		
Step 2	Age	0.08** [0.06, 0.10]		
	Sex	−0.01 [−0.03, 0.00]		
	MPE	0.01 [−0.01, 0.02]		
	Number of clusters	0.10** [0.05, 0.14]	0.961** [0.96, 0.96]	0.535
	Cluster size	0.28** [0.23, 0.34]		
	Mean cluster size	−0.01 [−0.04, 0.02]		
	Number of switches	0.69** [0.66, 0.71]		
Semantic fluency				
Step 1	Age	0.63** [0.57, 0.69]	0.431** [0.38, 0.48]	0.431
	Sex	−0.02 [−0.08, 0.03]		
	Mean parents' education	0.18** [0.12, 0.24]		
Step 2	Age	0.04** [0.02, 0.07]		
	Sex	0.01 [−0.01, 0.03]		
	MPE	0.00 [−0.02, 0.02]		
	Number of clusters	0.03 [−0.01, 0.08]	0.936** [0.93, 0.94]	0.505
	Cluster size	0.51** [0.46, 0.55]		
	Mean cluster size	0.00 [−0.03, 0.04]		
	Number of switches	0.61** [0.59, 0.64]		

Note: LL, lower limits of a confidence interval; MPE, mean parents' education; UL, upper limits of a confidence interval. $^{**}p < 0.001$.

reader the impact of clustering and switching strategies upon verbal fluency TS, beyond the classic sociodemographic variables. Consistently with the literature, age and MPE were significantly associated with semantic and phonological fluency TS (i.e., Olabarrieta-Landa et al., 2017b; Tallberg et al., 2011; Van der Elst et al., 2011), but weakly compared with verbal fluency strategies. Actually, when strategies were introduced in the model, MPE disappeared, although age remained, but with reduced weight (beta 0.008 and 0.004, respectively).

For both VFT TS, NS was the strategy with the highest weight (beta of 0.69 and 0.61, respectively), followed by CS for semantic TS (beta of 0.51). NC also presented a significant association with phonological TS (beta 0.10), but weaken compared with NS and CS. Other authors had also found NS as the strongest variable related to phonological in Portuguese and Spanish-speaking participants (Becker et al., 2019; Nieto et al., 2008; Sánchez-López et al., 2021) and semantic TS in Spanish, Hebrew and Malayan-speaking participants (John & Rajashekhar, 2014; Kavé et al., 2008; Nieto et al., 2008). In contrast, Becker et al. (2019) found NC as the best predictor for semantic TS in Portuguese-speaking participants, as Koren et al. (2005) did for phonological and semantic TS in Hebrew-speaking participants. These results support Kavé et al.'s (2008) idea that NS may be a better measure of frontal component of efficient strategic retrieval and inhibition than NC, according to them, because it takes single words switching into account. Moreover, Becker et al. (2019) speculated that switching may have a larger contribution compared with clustering, and that this may be associated with the development of executive functions (related to frontal lobe maturation). CS has been also related to phonological and semantic TS in Koren et al. (2005). This strategy has been linked to temporal component (vocabulary) (Koren et al., 2005), and due to its greater weight for semantic TS compared with phonologic, it seems that vocabulary size may be especially relevant for good performance in semantic VFT. Finally, MCS was no related to any VFT TS, as others have reported before for semantic (Koren et al., 2005; Nieto et al., 2008; Sánchez-López et al., 2021) or phonologic (Kavé et al., 2008; Koren et al., 2005; Nieto et al., 2008) TSs, although Becker et al. (2019) have found positive significant association for both VFT TSs. Our data support

TABLE 5 Final multiple linear regression models

Score		NC	CS	NS
		b CI$_{95\%}$ [LL, UL]	b CI$_{95\%}$ [LL, UL]	b CI$_{95\%}$ [LL, UL]
F	(Intercept)	1.02** [0.91, 1.13]	1.60** [1.47, 1.73]	4.38** [4.20, 4.55]
	Age	0.09** [0.06, 0.11]	0.12** [0.08, 0.16]	0.47** [0.41, 0.52]
	Age^2	0.01** [0.00, 0.02]	–	–
	R^2 [95% CI]	$R^2 = 0.084$**	$R^2 = 0.050$**	$R^2 = 0.308$**
		95% CI [0.05, 0.12]	95% CI [0.02, 0.09]	95% CI [0.25, 0.36]
A	(Intercept)	1.31** [1.24, 1.39]	1.80** [1.69, 1.92]	5.16** [4.97, 5.36]
	Age	0.13** [0.11, 0.15]	0.16** [0.13, 0.20]	0.48** [0.42, 0.54]
	MPE	0.04** [0.02, 0.06]	0.06** [0.02, 0.09]	0.07** [0.02, 0.13]
	R^2 [95% CI]	$R^2 = 0.183$**	$R^2 = 0.130$**	$R^2 = 0.285$**
		95% CI [0.13, 0.23]	95% CI [0.08, 0.18]	95% CI [0.23, 0.34]
S	(Intercept)	1.59** [1.49, 1.70]	2.50** [2.30, 2.69]	4.62** [4.34, 4.89]
	Age	0.09** [0.07, 0.11]	0.15** [0.11, 0.19]	0.34** [0.28, 0.40]
	School	−0.30** [−0.45, −0.15]	−0.39** [−0.67, −0.12]	−0.64** [−1.03, −0.25]
	R^2 [95% CI]	$R^2 = 0.100$**	$R^2 = 0.075$**	$R^2 = 0.172$**
		95% CI [0.06, 0.14]	95% CI [0.04, 0.11]	95% CI [0.12, 0.22]
M	(Intercept)	1.55** [1.48, 1.63]	2.65** [2.51, 2.80]	4.27** [3.96, 4.58]
	Age	0.09** [0.07, 0.12]	0.09** [0.05, 0.14]	0.46** [0.39, 0.52]
	Age^2	–	–	0.03** [0.01, 0.05]
	MPE	–	–	0.11** [0.05, 0.17]
	R^2 [95% CI]	$R^2 = 0.087$**	$R^2 = 0.023$**	$R^2 = 0.240$**
		95% CI [0.05, 0.13]	95% CI [0.01, 0.05]	95% CI [0.18, 0.29]
R	(Intercept)	1.44** [1.37, 1.52]	2.16** [2.03, 2.28]	4.19** [4.00, 4.38]
	Age	0.09** [0.07, 0.11]	0.14** [0.10, 0.18]	0.39** [0.33, 0.45]
	MPE	–	0.05** [0.01, 0.08]	–
	R^2 [95% CI]	$R^2 = 0.081$**	$R^2 = 0.079$**	$R^2 = 0.207$**
		95% CI [0.05, 0.12]	95% CI [0.04, 0.12]	95% CI [0.16, 0.26]
P	(Intercept)	1.61** [1.53, 1.70]	2.45** [2.30, 2.60]	5.54** [5.31, 5.76]
	Age	0.08** [0.06, 0.11]	0.13** [0.08, 0.17]	0.50** [0.43, 0.56]
	MPE	–	–	0.06 [−0.01, 0.12]
	Age × MPE	–	–	0.03** [0.01, 0.05]
	R^2 [95% CI]	$R^2 = 0.052$**	$R^2 = 0.044$**	$R^2 = 0.245$**
		95% CI [0.02, 0.09]	95% CI [0.02, 0.08]	95% CI [0.19, 0.30]
Animals	(Intercept)	3.43** [3.32, 3.54]	5.93** [5.71, 6.14]	7.91** [7.68, 8.14]
	Age	0.20** [0.17, 0.24]	0.36** [0.29, 0.42]	0.51** [0.44, 0.58]
	MPE	0.06** [0.03, 0.09]	0.16** [0.10, 0.22]	–
	R^2 [95% CI]	$R^2 = 0.190$**	$R^2 = 0.180$**	$R^2 = 0.228$**
		95% CI [0.14, 0.24]	95% CI [0.13, 0.23]	95% CI [0.18, 0.28]
Fruits	(Intercept)	2.36** [2.27, 2.45]	3.60** [3.46, 3.74]	6.55** [6.36, 6.73]
	Age	0.15** [0.12, 0.18]	0.21** [0.16, 0.25]	0.42** [0.36, 0.47]
	MPE	0.05** [0.02, 0.07]	0.06** [0.02, 0.10]	0.12** [0.07, 0.17]
	R^2 [95% CI]	$R^2 = 0.162$**	$R^2 = 0.128$**	$R^2 = 0.262$**
		95% CI [0.11, 0.21]	95% CI [0.08, 0.17]	95% CI [0.21, 0.31]

Note: b represents unstandardized regression weights; LL and UL indicate the lower and upper limits of a confidence interval, respectively. CS, cluster size; NC, number of clusters; NS, number of switches. **$p < 0.001$.

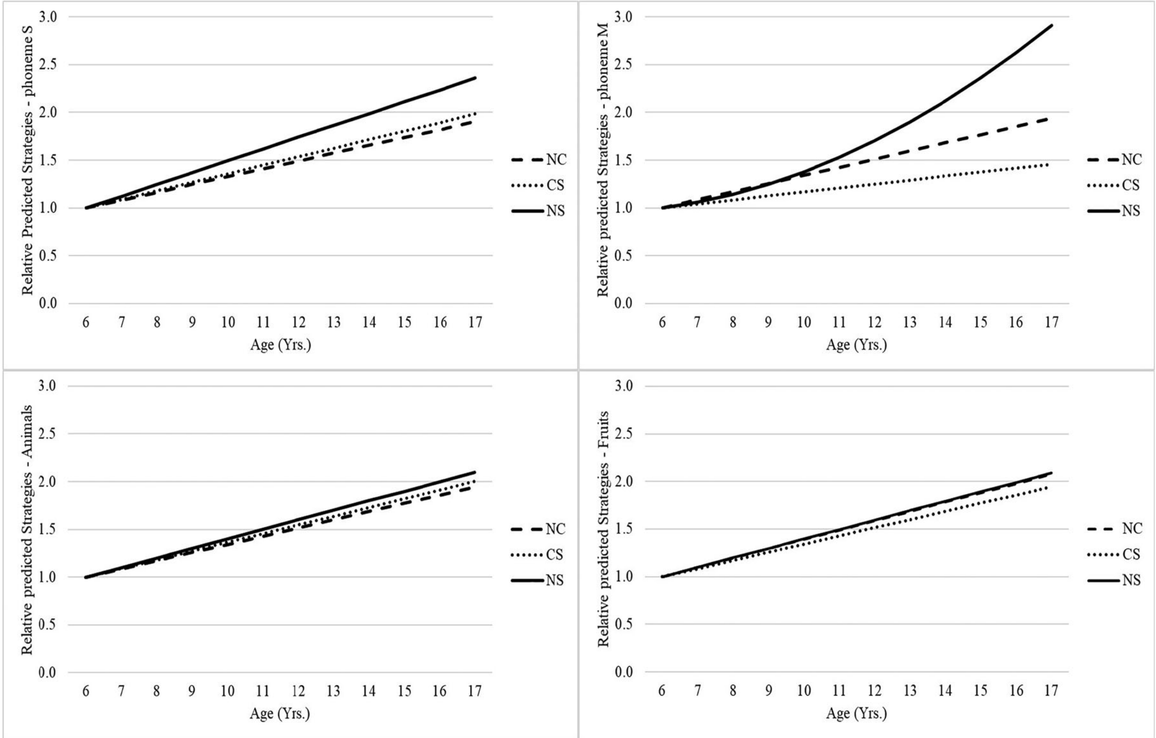

FIGURE 1 Relative predicted clustering and switching strategies in two phonemes and categories

John and Rajashekhar's (2014) idea that MCS may not be a critical measure or at least its contribution towards TS is minimal.

Regarding relevant predictor to generate normative data for clustering and switching strategies, in this study, age was found as the strongest predictor for strategies in all phonemes and semantic categories, so that while children grow, they tend to use more of these strategies. Moreover, age^2 was relevant too for NC in /f/ phoneme and NS in /m/ phoneme. These results support previous evidence of more NC, and NS in both VFT test with age (Becker et al., 2019; Hurks et al., 2010; John & Rajashekhar, 2014; John, Rajasherkhar & Guddattu, 2016; Kavé et al., 2008; Koren et al., 2005; Nieto et al., 2008; Tallberg et al., 2011). This increase can be related to more flexibility and set shifting retrieval strategies, considered as higher cognitive functions and related to frontal lobe maturation, resulting in an increase employment of switching strategies (Becker et al., 2019). Moreover, schooling exposure increase with age, and John, Rajashekhar and Guddatt (2016) suggested that it may also help children to enhance efficiency sound-based word retrieval mechanism during phonological VFT. Regarding CS, in this study its use increased with age, and this is consistent with previous studies in both VFT (Kavé et al., 2008; Nieto et al., 2008; Tallberg et al., 2011). The growth use of CS strategy has been linked to the temporal components of lexicon–semantic increase knowledge (Sánchez-López et al., 2021) and also to further exposure and use of vocabulary (Kavé et al., 2008).

However, contrary findings have been also reported in the literature, such as CS decrease with age in phonological fluency (Becker et al., 2019; Sauzeon et al., 2004), increase with age during semantic fluency (Sauzeon et al., 2004), or even no relationship with age in semantic fluency (Becker et al., 2019). Moreover, Sauzeon et al. (2004), unlike our study, reported a decrease in semantic fluency according to age. These discrepancies may be due to methodological issue, such as different consideration of CS (i.e., counting from the first or second word; Hurks et al., 2010; Kavé et al., 2008), sample size or age range of the samples.

Development of MCS remains still unclear; some authors found that it increases with age in semantic fluency (Hurks et al., 2010; Kavé et al., 2008), while others found its drop in phonological fluency (Becker et al., 2019; Sauzéon et al., 2004). However, other studies found not significant associated with age in semantic (Chami et al., 2018; John & Rajashekhar, 2014; Nieto et al., 2008) or phonological fluency (Kavé et al., 2008; Nieto et al., 2008), similarly to our study. Our results reinforce the idea of John and Rajashekhar (2014) about MCS as not critical measure or contributes minimal during clustering analysis, but caution is needed as several discrepancy arise between studies (i.e., sample size, participants' age range, clustering and switching scoring criteria).

MPE have been previously linked to VFT TSs (i.e., Olabarrieta-Landa et al., 2017b; Van der Elst et al., 2011), at so, it could be also associated with strategies. Only Hurks et al. (2010) explored MPE on clustering and switching in children population, so that children whose caregivers had higher education achieved higher MCS in animals' category. According to them, MPE may be affecting automatic lower cognitive functions, such as MCS, rather than higher order cognitive functions, such as NS and NC. However, our results contradict this hypothesis since those children and adolescents whose parents had more years of education obtained more NC (at /a/ phoneme, animals and fruits categories) and NS (at /a/ and /m/ phonemes, and fruits category), and larger CS (at /a/ and /r/ phonemes, and animals and fruits categories).

Moreover, few studies have explored environmental factors other than MPE that can be related to socio-economic status (SES). In this study, type of school was considered as an indicator of SES because in Colombia public schools present high homogeneity of SES, thus, a very low probability of having students from different SES attending to the same institution (Duarte et al., 2012). In previous studies, SES has been explored but for VFT TSs (i.e., Prigatano et al., 2008). Only Becker et al. (2019) did with strategies but failed to obtain any significant association, except for discrepancy score between semantic and phonological TSs, in which children from private school showed greater discrepancy. In the present study, those participants attending to private school generated more NC, NS and larger CS in /s/ phoneme. This can be due to the fact that this phoneme may be challenging for Colombian children and adolescents since its sound is also present in C and Z letters ('seseo' phenomenon). School may help children and adolescents to develop greater knowledge of their language phonological and orthographical rules, increasing the probability of using not only phonological-based combination searching strategies, but also orthography-based combination (Becker et al., 2019).

Sex was not related to any cluster or switching measures, consistent with the increasing evidence on lack of sex influence on verbal fluency (i.e., Chami et al., 2018; Hurks et al., 2010; Jhon & Rajashekhar, 2014; John, Rajashekhar & Guddattu, 2016; Nieto et al., 2008; Tallberg et al., 2011).

Lastly, most of the studies followed the traditional approach (use of means and SD) to generate normative data, which presents two main problems: it establishes a single norm for the whole population, ignoring possible demographic factors effects, or it allows to establish different norms but per subsample (according to demographic variables), splitting up the sample and reducing sample size and norms precision (Innocenti et al., 2021). However, the regression-based approach taken in this study allows to overcome these problems (Innocenti et al., 2021).

Implications

The results of the present study have several implications. Having a clustering and switching scoring guideline adapted to Colombian context may encourage clinicians and researcher to include these measures when assessing verbal fluency. VFT are free neuropsychological tools that can offer in-depth knowledge of the underlying cognitive processes if clinicians/researchers analyse not only TS, but also strategies. Strategies allow to catch the underlying cognitive procedure failure in children with neurodevelopmental or acquired disorders (Pastor-Cerezuela et al., 2016; Schworer et al., 2021; Weckerly et al., 2001). Moreover, VFT TSs are associated with age, but also with clustering and switching strategies; therefore, variables that may can be trained. For our knowledge, this is the first study to include both linear and quadratic effect of age and MPE among verbal fluency strategies. Moreover, we included two indicators of SES (MPE and type of school) in the analysis, generating norms for Colombian children and adolescents population.

Limitations

This study includes some limitations that should be considered. First, the scoring guidelines proposed for clustering and switching, and the normative data obtained was based on Colombian children and adolescents' reproductions, as so, on a population that has not fully developed their language competencies. Therefore, caution should be paid when using the scoring proposal with adults. Second, verbal fluency may be influenced by other factors that have not been included in the present study, such as, bilingualism. It is well-known that bilinguals tend to perform differently in these tasks compared with monolinguals (Bialystok & Viswanathan, 2009; Friesen et al., 2015; Luo et al., 2010). Third, the reader may want to use other researchers' proposals, as there is no standardized method. For example, Abwender et al. (2001) proposed two types of switching: cluster switching (shift between clusters) and hard switching (shift between single words). Finally, the cross-sectional nature of the study using population between 6 and 17 years old do not allow to explore the development of verbal fluency strategies.

CONCLUSIONS

The present study described the Colombian adaptation of the scoring guidelines for clustering and switching strategies, and provided normative data of these strategies for children and adolescents between 6 and 17 years old. Knowing VFT performance, including strategy development and use in healthy children and adolescents may be useful for clinical settings. We encourage clinicians to include not only TS, but also a careful analysis of strategies that may be more informative of the underlying cognitive processes failure than TS.

ACKNOWLEDGEMENTS

Diego Rivera and Laiene Olabarrieta Landa contributed equally to this paper.

Open access funding provided by Universidad Pública de Navarra.

CONFLICT OF INTEREST STATEMENT

All authors declare no financial interests or potential conflicts of interest related directly or indirectly to this work.

DATA AVAILABILITY STATEMENT

The data presented in this study are not publicly available for reasons of data protection.

ORCID

Diego Rivera https://orcid.org/0000-0001-7477-1893
Laiene Olabarrieta-Landa https://orcid.org/0000-0002-8305-8720

REFERENCES

Abwender, D.A., Swan, J.G., Bowerman, J.T. & Connolly, S.W. (2001) Qualitative analysis of verbal fluency output: review and comparison of several scoring methods. *Assessment*, 8(3), 323–338.

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

Anderson, P. (2002) Assessment and development of executive function (EF) during childhood. *Child Neuropsychology*, 8(2), 71–82. Available from: https://doi.org/10.1076/chin.8.2.71.8724

Anderson, V.A., Anderson, P., Northam, E., Jacobs, R. & Catroppa, C. (2001) Development of executive functions through late childhood and adolescence in an Australian sample. *Developmental Neuropsychology*, 20(1), 385–406.

Arán-Filippetti, V. (2011) Fluidez verbal según tipo de tarea, intervalo de tiempo y estrato socioeconómico, en niños escolarizados. *Anales de psicología*, 27(3), 816–826.

Arán-Filippetti, V. & Allegri, R.F. (2011) Verbal fluency in Spanish-speaking children: Analysis model according to task type, clustering, and switching strategies and performance over time. *The Clinical Neuropsychologist*, 25(3), 413–436.

Artiola, L., Hermosillo, D., Heaton, R. & Pardee, R.E. (1999) Manual de normas y procedimientos para la batería neuropsicológica en español [Manual de normas y procedimientos para la batería neuropsicológica en españo]. Tucson: AZ.

Azuma, T. (2004) Working memory and perseveration in verbal fluency. *Neuropsychology*, 18(1), 69–77.

Becker, N. & Salles, J.F.D. (2016) Methodological criteria for scoring clustering and switching in verbal fluency tasks. *Psico-usF*, 21(3), 445–457.

Becker, N., Piccolo, L.D.R. & Salles, J.F.D. (2019) Verbal fluency development across childhood: normative data from Brazilian–Portuguese speakers and underlying cognitive processes. *Archives of Clinical Neuropsychology*, 34(7), 1217–1231.

Begeer, S., Wierda, M., Scheeren, A.M., Teunisse, J.P., Koot, H.M. & Geurts, H.M. (2014) Verbal fluency in children with autism spectrum disorders: clustering and switching strategies. *Autism*, 18(8), 1014–1018.

Bialystok, E. & Viswanathan, M. (2009) Components of executive control with advantages for bilingual children in two cultures. *Cognition*, 112(3), 494–500.

Brown, L., Sherbenou, R.J. & Johnsen, S.K. (2009) Test de inteligencia no verbal TONI-2. Madrid: TEA ediciones.

Chami, S., Munro, N., Docking, K., McGregor, K., Arciuli, J., Baker, E. & Heard, R. (2018) Changes in semantic fluency across childhood: normative data from Australian-English speakers. *International Journal of Speech–Language Pathology*, 20(2), 262–273.

Delgado-Álvarez, A., Matias-Guiu, J.A., Delgado-Alonso, C., Hernández-Lorenzo, L., Cortés-Martínez, A., Vidorreta, L. ... & Matias-Guiu, J. (2021) Cognitive processes underlying verbal fluency in multiple sclerosis. *Frontiers in Neurology*, 11, 629183.

Delis, D.C., Kaplan, E. & Kramer, J.H. (2001) *Delis–Kaplan executive function system*. San Antonio, TX: Psychological Corporation.

Duarte, J., Bos, M.S. & Moreno, M. (2012) *Quality, equality and equity in Colombian education (analysis of the SABER 2009 test)*. Inter-American Development Bank.

Fitzpatrick, S., Gilbert, S. & Serpell, L. (2013) Systematic review: are overweight and obese individuals impaired on behavioural tasks of executive functioning? *Neuropsychology Review*, 23(2), 138–156.

Friesen, D.C., Luo, L., Luk, G. & Bialystok, E. (2015) Proficiency and control in verbal fluency performance across the lifespan for monolinguals and bilinguals. *Language, Cognition and Neuroscience*, 30(3), 238–250.

García, E., Rodríguez, C., Martín, R., Jiménez, J.E., Hernández, S. & Díaz, A. (2012) Test de Fluidez Verbal: datos normativos y desarrollo evolutivo en el alumnado de primaria. *European Journal of Education and Psychology*, 5(1), 53–64.

Gonçalves, H.A., Cargnin, C., Jacobsen, G.M., Kochhann, R., Joanette, Y. & Fonseca, R.P. (2017) Clustering and switching in unconstrained, phonemic and semantic verbal fluency: the role of age and school type. *Journal of Cognitive Psychology*, 29(6), 670–690.

Henry, J.D. & y Crawford, J.R. (2004) A meta-analytic review of verbal fluency performance following focal cortical lesions. *Neuropsychology*, 18(2), 284–295.

Hurks, P.P., Schrans, D., Meijs, C., Wassenberg, R., Feron, F.J.M. & Jolles, J. (2010) Developmental changes in semantic verbal fluency: analyses of word productivity as a function of time, clustering, and switching. *Child Neuropsychology*, 16(4), 366–387.

Innocenti, F., Tan, F.E., Candel, M.J. & van Breukelen, G.J. (2021) Sample size calculation and optimal design for regression-based norming of tests and questionnaires. *Psychological Methods*, 28(1), 89–106.

John, S. & Rajashekhar, B. (2014) Word retrieval ability on semantic fluency task in typically developing Malayalam-speaking children. *Child Neuropsychology*, 20(2), 182–195.

John, S., Rajashekhar, B. & Guddattu, V. (2016) Word retrieval ability on phonemic fluency in typically developing children. *Applied Neuropsychology: Child*, 5(4), 252–263.

John, S., Rajashekhar, B. & Guddattu, V. (2018) Analysis of verbal fluency output on semantic Categories of 'food 'and 'vehicle' in typically Developing Malayalam speaking children. *Psychology of Language and Communication*, 22(1), 328–353.

Kavé, G., Kigel, S. & Kochva, R. (2008) Switching and clustering in verbal fluency tasks throughout childhood. *Journal of Clinical and Experimental Neuropsychology*, 30(3), 349–359.

Kircher, T., Nagels, A., Kimer-Veselinovic, A. & Krach, S. (2011) Neural correlates of rhyming vs. lexical and semantic fluency. *Brain Research*, 1391, 71–80.

Koo, T.K. & Li, M.Y. (2016) A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, 15(2), 155–163.

Koren, R., Kofman, O. & Berger, A. (2005) Analysis of word clustering in verbal fluency of school-aged children. *Archives of Clinical Neuropsychology*, 20(8), 1087–1104.

Kovacs, M. (1992) *Children depression inventory CDI (manual)*. Toronto: Multihealth systems.

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

Luo, L., Luk, G. & Bialystok, E. (2010) Effect of language proficiency and executive control on verbal fluency performance in bilinguals. *Cognition*, 114(1), 29–41.

Malloy-Diniz, L.F., Bentes, R.C., Figueiredo, P.M., Brandão-Bretas, D., Costa-Abrantes, S., Parizzi, A.M., Borges Leite, W. & Salgado, J.V. (2007) Normalización de una batería de tests para evaluar las habilidades de comprensión del lenguaje, fluidez verbal y denominación en niños brasileños de 7 a 10 años: resultados preliminares. *Revista De Neurologia*, 44(5), 275–80.

Martins, I., Vieira, R., Loureiro, C. & Santos, M. (2007) Speech rate and fluency in children and adolescents. *Child Neuropsychology*, 13(4), 319–332.

Martins-Oliveira, R., Mograbi, D.C., Andrade Gabrig, I. & Charchat-Fichman, H. (2016) Normative data and evidence of validity for the Rey auditory verbal learning test, verbal fluency test, and Stroop test with Brazilian children. *Psychology & Neuroscience*, 9(1), 54–67.

Mielnik, A., Łockiewicz, M. & Bogdanowicz, M. (2015) Semantic and phonological verbal fluency in students with dyslexia. *Acta Neuropsychologica*, 13(3), 253–266.

Nieto, A., Galtier, I., Barroso, J. & Espinosa, G. (2008) Fluencia verbal en niños españoles en edad escolar: estudio normativo piloto y análisis de las estrategias organizativas. *Revista de neurología*, 46(1), 2–6.

Olabarrieta Landa, L., Landa Torre, E., López-Mugartza, J.C., Bialystok, E. & Arango-Lasprilla, J.C. (2017a) Verbal fluency tests: developing a new model of administration and scoring for Spanish language. *Neurorehabilitation*, 41(2), 539–565.

Olabarrieta-Landa, L., Rivera, D., Lara, L., Rute-Pérez, S., Rodríguez Lorenzana, A., Galarza-del-Angel, J., Peñalver Guia, A.I., Ferrer-Cascales, R., Velázquez-Cardoso, J., Campos Varillas, A.I., Ramos-Usuga, D., Chino-Vilca, B., Aguilar Uriarte, M.A., Martín-Lobo, P., García de la Cadena, C., Postigo-Alonso, B., Romero-García, I., Rabago Barajas, B.V., Irías Escher, M.J. & Arango-Lasprilla, J.C. (2017b) Verbal fluency tests: normative data for Spanish-speaking pediatric population. *Neurorehabilitation*, 41(3), 673–686. Available from: https://doi.org/10.3233/NRE-172240.

Olabarrieta-Landa, L., Benito-Sánchez, I., Alegret, M., Gailhajanet, A., Landa Torre, E., López-Mugartza, J.C. & Arango-Lasprilla, J.C. (2019) Letter verbal fluency in Spanish-, Basque-, and Catalan-speaking individuals: does the selection of the letters influence the outcome? *Journal of Speech, Language, and Hearing Research*, 62(7), 2400–2410.

Pastor-Cerezuela, G., Fernández-Andrés, M.I., Feo-Álvarez, M. & González-Sala, F. (2016) Semantic verbal fluency in children with and without autism spectrum disorder: relationship with chronological age and IQ. *Frontiers in Psychology*, 7, 921.

Prigatano, G.P., Gray, J.A. & Lomay, V.T. (2008) Verbal (animal) fluency scores in age/grade appropriate minority children from low socioeconomic backgrounds. *Journal of the International Neuropsychological Society*, 14(1), 143–147.

R Development Core Team. (2022) R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from http://www.R-project.org/

Rende, B., Ramsberger, G. & Miyake, A. (2002) Commonalities and differences in the working memory components underlying letter and category fluency tasks: a dual-task investigation. *Neuropsychology*, 16(3), 309–321.

Resch, C., Martens, R. & Hurks, P. (2014) Analysis of young children's abilities to cluster and switch during a verbal fluency task. *The Clinical Neuropsychologist*, 28(8), 1295–1310.

Riva, D., Nichelli, F. & Devoti, M. (2000) Developmental aspects of verbal fluency and confrontation naming in children. *Brain and Language*, 71, 267–284.

Rivera, D. & Arango-Lasprilla, J.C. (2017) Methodology for the development of normative data for Spanish-speaking pediatric populations. *NeuroRehabilitation*, 41(3), 581–592.

Rivera, D., Olabarrieta-Landa, L. & Arango-Lasprilla, J.C. (2017) Metodología para generar datos normativos en población colombiana de 6 a 17 años de edad. In: Arango-Lasprilla, J.C., Rivera, D. & Olabarrieta-Landa, L. (Eds.) *Neuropsicología infantil*. Bogotá: Manual Moderno, pp. 163–195.

Rivera, D., Olabarrieta-Landa, L., Van der Elst, W., Gonzalez, I., Ferrer-Cascales, R., Peñalver Guia, A.I., Rodriguez-Lorenzana, A., Galarza-del-Angel, J., Irías Escher, M.J. & Arango-Lasprilla, J.C. (2021) Regression-based normative data for children from Latin America: Phonological verbal fluency letters M, R, and P. *Assessment*, 28(1), 264–276.

Ruffieux, N., Njamnshi, A.K., Mayer, E., Sztajzel, R., Eta, S.C., Doh, R.F., Kengne, A.-M., Ngamaleu, R.N., Chanal, J., Verdon, V. & Hauert, C.A. (2009) Neuropsychology in Cameroon: first normative data for cognitive tests among school-aged children. *Child Neuropsychology*, 16(1), 1–19.

Sánchez-López, M.D.P., Lapuente, F.R. & García-Rubio, M.J. (2021) Verbal fluency in school-aged spanish children: Analysis of clustering and switching organizational strategies, employing different semantic categories and letters. *Anales de Psicología/Annals of Psychology*, 37(3), 449–458.

Sauzéon, H., Lestage, P., Raboutet, C., N'Kaoua, B. & Claverie, B. (2004) Verbal fluency output in children aged 7–16 as a function of the production criterion: qualitative analysis of clustering, switching processes, and semantic network exploitation. *Brain and language*, 89(1), 192–202.

Schworer, E.K., Belizaire, S., Hoffman, E.K. & Esbensen, A.J. (2021) Semantic verbal fluency in youth with Down syndrome: analysis of conventional and contextual cluster formation. *Brain Sciences*, 12(1), 9.

Takács, Á., Kóbor, A., Tárnok, Z. & Csépe, V. (2014) Verbal fluency in children with ADHD: strategy using and temporal properties. *Child Neuropsychology*, 20(4), 415–429.

Tallberg, I.M., Carlsson, S. & Lieberman, M. (2011) Children's word fluency strategies. *Scandinavian Journal of Psychology*, 52(1), 35–42.

Troyer, A.K. (2000) Normative data for clustering and switching on verbal fluency tasks. *Journal of Clinical and Experimental Neuropsychology*, 22(3), 370–378.

Troyer, A.K., Moscovitch, M. & Winocur, G. (1997) Clustering and switching as two components of verbal fluency: evidence from younger and older healthy adults. *Neuropsychology*, 11, 138–146.

Van der Elst, W., Hurks, P., Wassenberg, R., Meijs, C. & Jolles, J. (2011) Animal verbal fluency and design fluency in school aged children: effects of age, sex, and mean level of parental education, and regression-based normative data. *Journal of Clinical and Experimental Neuropsychology*, 33(9), 1005–1015.

Villodre, R., Sánchez-Alfonso, A., Brines, L., Núñez, A.B., Chirivella, J., Ferri, J. & Noé, E. (2006) Verbal fluency tasks in a Spanish sample of young adults (20–49 years of age): normative data of clustering and switching strategies. *Neurología*, 21(3), 124–130.

Wagner, S., Sebastian, A., Lieb, K., Tüscher, O. & Tadic, A. (2014) A coordinate-based ALE functional MRI meta-analysis of brain activation during verbal fluency tasks in healthy control subjects. *BMC Neuroscience*, 15(19), 1–13. Available from: https://doi.org/10.1186/1471-2202-15-19

Weckerly, J., Wulfeck, B. & Reilly, J. (2001) Verbal fluency deficits in children with specific language impairment: slow rapid naming or slow to name? *Child Neuropsychology*, 7(3), 142–152.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Álvarez Medina, M.N., Vergara Moragues, E.V., Arango-Lasprilla, J.C., Restrepo Botero, J.C., Calderón Chagualá, J.A., Rivera, D. et al. (2023) Phonological and semantic verbal fluency test: Scoring criteria and normative data for clustering and switching strategies for Colombian children and adolescents. *International Journal of Language & Communication Disorders*, 1–15. https://doi.org/10.1111/1460-6984.12891