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Examining qualitative and quantitative features of verbal fluency tasks to investigate the mental lexicon in postpartum women: A neuropsychological approach of executive functions applied to language

During the postpartum period, women experience neurobiological and psychosocial variations that impact language functioning. Word production in verbal fluency tasks (VFTs) is a cognitive indicator of associative (semantic categorization and phonological analysis) and executive (inhibitory control and cognitive flexibility) processes. Also, a linguistic analysis allows for understanding production strategies (e.g., orthographic and use of rhymes), with multivariate statistics facilitating cluster identification of the most common words. Considering these approaches, this study aimed to optimize semantic and phonological VFT analysis for the identification of postpartum women's mental lexicon using quantitative and qualitative scores. These outcomes were evaluated together with sociodemographic and reproductive data of 100 postpartum women (from Argentina). Mental lexicon description was statistically improved and showed that multiparous women clustered words more concisely than primiparous women, with increased correct words and better organizational strategies. In sum, female reproductive history improved VFT outcomes. The current results also show that factor analysis can optimize the neuropsychological study of language structuring.

Key words: postpartum period, cognition, epidemiologic methods, parity, women's health

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The puerperium is a stage in the reproductive life of women that represents a biological, psychological, and social transition (Pawluski et al., 2016). This has a strong impact on their cognitive state, presenting numerous functional implications that are prospective (Carrizo et al., 2020; Fox et al., 2021). In this regard, there is little scientific evidence and poor specific clinical follow–up, so the cognitive characteristics of postpartum women require an innovative approach which includes both productive criteria and executive strategies.

Oral production implies the dynamic interaction between semantic and executive activity which can be studied from linguistic evidence in verbal fluency tasks (VFTs, Marino et al., 2011b). In this sense, the number of correct and incorrect words produced and their organization and recovery strategies, as well as groupings, switches, and returns, can be considered in order to infer the processes involved in linguistic production (Goñi et al., 2011; Gonçalves et al., 2017). Their analysis shows the procedural modality of production and the associations through which the lexicon is recovered (Berto & Galaverna, 2016), which can be used as a neuropsychological indicator of executive functions (Hussey & Novick, 2012).

Verbal fluency is a complex cognitive task that requires the intervention of multiple cognitive processes and that is governed by executive functions (Indefrey & Levelt, 2004; Lázaro & Solís, 2008). Verbal fluency is based on executive and linguistic components (Aita et al., 2018; Luo et al., 2010). In this sense, as Indefrey and Levelt (2004) postulate, the study of verbal fluency makes it possible to demonstrate the top–down processes of executive control and central linguistic processes. Indeed, both Luu et al. (2015) and Shao et al. (2014) have shown that executive control and verbal skills impact performance on verbal fluency tests. Both phonemic and semantic fluency are similarly related to multiple dimensions of executive functions and verbal ability. Thus, they should be considered executive language tasks (Aita et al., 2018; Kraan et al., 2013; Shao et al., 2014). Furthermore, VFTs predict cognitive flexibility and inhibition, which are part of the executive functions (Amunts et al., 2021), with deficits in verbal fluency reflecting an executive decline (Nevado et al., 2021). Moreover, word clustering, switching, returning, overlapping, and the use of isolated words have been shown to be reliable indicators of executive processing. Thus, there is an increasing interest in using these nontraditional VFTs measures (Sánchez–López et al., 2021; Hurks et al., 2010).

Individual cognitive state is susceptible to reproductive and health factors during puerperium, such as parity and socioenvironmental conditions, among others (Miranda, Scotta et al., 2021). Given that linguistic processing depends on cognitive state, a concomitant compromising of it by these factors would be expected. Furthermore, the reproductive experience of primiparity implies behavioral and neuroendocrine changes that differ in later experiences (i.e., multiparity, Parsons et al, 2004). Pregnant women experience neuroendocrine changes and sociocultural conditioning, which result in a complex process of neural reorganization leading to behavioral and cognitive variations, with physiological processes such as

neuroplasticity, synaptic pruning, and dendritic remodeling being involved (Carrizo et al., 2020). These changes persist to adapt women to motherhood, modifying their verbal learning and memory. Moreover, the first pregnancy induces unique long–term changes (Hoekzema et al., 2017) for more efficient performance in future mothering (Orchard et al., 2019). For example, primiparous women exhibit lower concentration and more behavioral differences than multiparous ones (Parsons et al., 2004; Pereira & Ferreira, 2016). This motivates a comparative study of verbal fluency between primiparous and multiparous women.

Traditionally, VFTs make use of hierarchical cluster analysis (HCA) complemented with correspondence analysis (CoA), with data reduction and use of complex mathematical developments (Barbero García et al., 2011). To overcome this, exploratory factor analysis (EFA), which currently is one of the most widely used statistical techniques (Méndez Martínez & Rondón Sepúlveda, 2012), was proposed to evaluate VFTs. In this sense, it is also necessary to identify the most appropriate rotation method to psychologically interpret the proven factors (Barbero García et al., 2011). The estimation of the semantic structure and grouping strategies enables understanding complex cognitive processes, such as executive functions, under normal and pathological conditions (Sumiyoshi et al., 2018). Consequently, it was hypothesized that the EFA would optimize the study of VFTs applied in women during their puerperium, which is conditioned by reproductive factors.

Material and Methods

Study Design and Participants

This cross–sectional study was performed on 100 postpartum women from Córdoba province, Argentina, who were interviewed face–to–face by speech and language therapists. The sample was recruited from Primary Care Units of the public health system, the Maternal Neonatal Hospital "Prof. Dr. Ramón Carrillo," and the Faculty of Medical Sciences. The inclusion criteria were: adult ($\geq$ 18 years old), Córdoba inhabitant, postpartum (first six months), and breastfeeding. Exclusion criteria were pregnancy, alcohol and drug abuse, current active disease, and neuropathology or psychological conditions (e.g., depression).

Optimal sample size conditions were used (error < 0.10, power of 80%, and confidence of 95%), which were calculated from births in the area in the previous year, as reported by the General Directorate of Statistics and Censuses of Córdoba. Women signed an informed consent form before being voluntarily included. Data collection took place from April 2017 to April 2020. This study was approved by the corresponding Ethics Committee.

Women's Demographic Characteristics

Similar to previous studies (Miranda, Cortez et al., 2021), self–reported information was collected about age (years), nationality (Argentine or non–Argentine), partnership status (single or in couple), years of education (≥ 12 years or < 12 years), employment (formal employment or informal employment/unemployment), parity (primiparous or multiparous), type of breastfeeding (exclusive or nonexclusive), and postpartum period (days).

Neuropsychological Evaluation of Language

Linguistic functioning was evaluated using four VFTs: two phonological tasks with direct instructions (initial letter "P" and "F"), one semantic (animals) and one phonological with indirect instructions (words without "A"). The application of the VFTs followed the procedure proposed by Marino et al. (2011a). The time allotted for each test was one minute (Lezak et al., 2012). All the words were recorded on a spreadsheet and each correct answer was scored with one point. Intrusions (words that did not belong to the required semantic field or did not comply with the phonological instruction) and perseverations (the repetition of a previous response) were considered incorrect.

Clinicians and researchers must select the type of VFTs consciously according to specific objectives in order to determine task difficulty and the different cognitive functions involved (Strauss et al., 2006). Herein, three phonological tasks and one semantic task were selected given their differential difficulty, with phonological VFTs (p–VFTs) requiring a more elaborate strategy and organization than semantic ones (s–VFTs). Phonological tasks depend on subcortical frontal circuits, particularly in the left hemisphere (Robinson et al., 2012), while temporal lobe structures are strongly associated with performance on semantic fluency tasks (Clark et al., 2014). On the other hand, the VFT type selection was based on recommendations for Spanish speakers. Some studies have focused on identifying a more suitable letter combination for a particular language by considering the frequency of letters in standard dictionaries or the number of words generated by participants in each letter of the alphabet of a given language (Kim et al., 2013; Beeldman et al., 2014). For this study, the letters "P" and "F" were used because they are the most functional for Spanish–speaking samples (Beltrán Dulcey & Solís–Uribe, 2012; García et al., 2012). The phonemic frequency influences processing time during VFTs, that is, words that begin with high–frequency phonemes will be more easily evoked than others (Rivadero, 2018). In fact, in the Argentine linguistic and cultural context, words that begin with "P" are very frequent (Zanin et al., 2010) and belong to the phonemic group of easy difficulty for VFTs, whereas the letter "F" is considered of intermediate difficulty (Marino et al., 2011a). Olabarrieta–Landa et al. (2019) showed that the average word production for the letter "P" was higher than

that for "F," which shows that the letter "F" implies greater difficulty than "P." Finally, an excluded letter–VFT was selected. The excluded letter "A" is one of the most widely used indirect VFTs in Spanish–speaking populations because it is sensitive for assessing inhibitory control (i.e., verbal response inhibition) and self–monitoring processes (Casals–Coll et al., 2013; Marino, & Alderete, 2010; O'Callaghan et al., 2013). Furthermore, this task is associated with verbal IQ and processing speed, as well as with other VFTs (Kraan et al., 2013). Excluded letter fluency was constructed as a more demanding analogue of phonemic fluency and as a measure of inhibition and strategic search abilities within an orthographic network (Bryan et al., 1997). Even age differences in favor of younger adults were found for excluded letter fluency (Hughes & Bryan, 2002). The difference between first letter– and excluded letter–VFTs lies in the fact that the latter are more demanding in psycholinguistic terms: once the lexical unit has been evoked, the subject must return to it, segment it into phonological units, analyze it, and accept or reject it depending on whether it meets the requirements of the phonological rule required by the task. In contrast, in the former case, the subject must evoke under a rule and then inhibit the noncorresponding units (Alonso–Sánchez & Alfaro–Faccio, 2019).

Quantitative and qualitative measures of verbal fluency were used. The quantitative measure corresponded to the total number of correct words generated (Lezak et al., 2012). The qualitative measure corresponded to the number of correct words and errors (perseverations and intrusions) and to the organizational strategies of the production of words: clustering (two or more consecutive words that belong to a same semantic or phonological subcategory), switching (transitions between groupings or isolated words), returning (the number of returns to a previously established cluster), and overlapping (a word that is included in more than one consecutive cluster). Likewise, the number and the mean size of clusters were calculated (Gonçalves et al., 2017).

For the analysis of the VFTs, the following indices were calculated:

- Number of correct words: This traditional scoring system consists of the sum of correct words produced in 60 seconds for each VFT. The performance on this indicator depends on the nature of the VFT used. For example, it is known that more words are produced in semantic tests than in phonological ones since they involve different task demands and cognitive retrieval strategies (Aita et al., 2018).
- Number of errors: Two types of errors are typically considered in VFTs, perseverations and intrusions. In this study, both the total amount and type of errors were counted. The number of intrusions consists of the number of those words that do not begin with the letter that was the evocation criterion, that did not belong to the requested semantic category, or that contained the specified vowel in the excluded–letter task (Rubiales et al., 2013). Proper nouns (e.g., people's names, countries, cities, brands), variations in size, number, or gender of a previously produced correct word (e.g., cat/cats/kitten), and words in

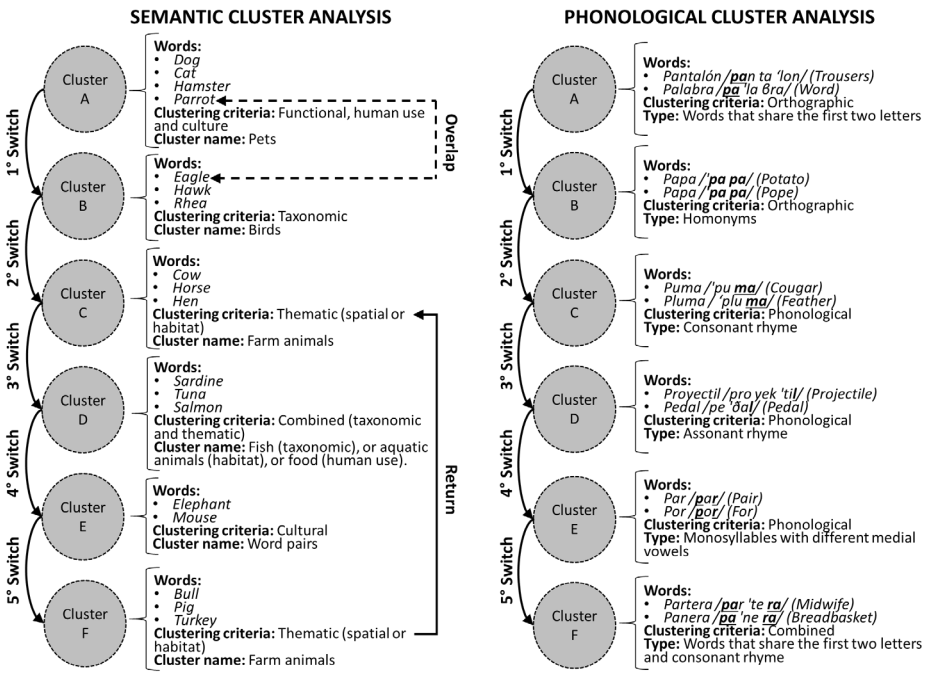
other languages were also considered intrusions (Charchat–Fichman et al., 2011). Functionally, intrusions are indicative of decreased inhibition and/or increased susceptibility to interference (Galaverna et al., 2016). On the other hand, perseverations consist of the repetition of a correct word previously produced in the same VFT, with failures in the mechanisms of inhibition and activation being involved (Charchat–Fichman et al., 2011; Galaverna et al., 2016). Therefore, working memory is important to monitor the products of retrieval and suppress previously recalled items, and not only to access new items, which is essential to prevent errors (Unsworth et al., 2011).

- Number of clusters: This index refers to the number of groups of words that correspond to the same category and require lexical–semantic networks (Hirshorn & Thompson–Schill, 2006; Olabarrieta–Landa, 2017). In addition, the mean cluster size was calculated by dividing the sum of words within clusters by the number of clusters. This type of score is considered an indicator of semantic memory, since cluster building is necessary to extract words from memory according to the categories given by accessing the mental lexicon (Sokołowski et al., 2020). Participants with higher educational levels outperform participants with lower ones on VFTs, therefore, the number of words generated depends on literacy (Jebahi, 2020). Also, s–VFTs tend to favor cluster generation (Methqal et al., 2019), with the temporal lobe mesial portion being its anatomical support (Wajman et al., 2019).
- Number of switches: In addition to verbal memory for cluster formation, cognitive flexibility and strategic search skills are required for cluster change, which is evidenced by counting switches (Amunts et al., 2020). These transitions between clusters require executive control networks, specifically those related to the dorsolateral prefrontal cortex (Patra et al., 2020; Wajman et al., 2019). The cluster size and switches are related. In this sense, a large cluster size indicates that the participant was highly productive and had fewer switches, whereas a small one indicates fewer responses before making a change or low production overall (Schworer, 2022). Furthermore, switching favors performance on phonological tasks due to phonemic variations during word production (Methqal et al., 2019).
- Number of isolated words: This qualitative strategy refers to the number of words of a specific semantic subcategory, not preceded or followed by a word from the same subcategory. Production of isolated words involves a more active strategic search between clusters, which is enhanced by education (Gonzales Da Silva et al., 2004).
- Number of returns: This is another qualitative strategy consisting of a reversion to a previous subcategory (Brincker et al., 2021). It is a high–level strategy that requires both episodic and working memory capacity to recall the previous category and evoked words and cognitive flexibility to perform a mental search for other words in the same category (Alegret et al., 2018).
- Number of overlaps: Overlapping or intersection is the ability to use words

from a cluster as a trigger to start the next one (Brincker et al., 2021). Overlapping is a highly effective strategy that is associated with the episodic buffer component of working memory, cognitive reserve capacity, and cognitive flexibility, and it is highly influenced by educational experience (Pereira et al., 2018).

Clusters were determined following the proposal by Troyer and Moscovitch (2006): the presence of semantic (for the s–VFT) and phonological (for the p–VFTs) clusters were identified. The types of semantic clusters were differentiated according to whether they responded to taxonomic or thematic criteria (Lin & Murphy, 2001). In the first case, types of clustering were distinguished according to the taxonomy of the named animals (e.g., birds). In the second case, spatial and functional relationships were distinguished, which included types of groupings according to habitat (e.g., African animals), human use (e.g., pets), or culture (e.g., word pairs, that is, words that are strongly related to being part of popular culture, e.g., "hare" and "tortoise," Nieto et al., 2008). In addition, there are different types of groupings that arise from the combination of different organizational strategies (e.g., jungle animals). The types of phonological clusters were classified into words that shared the first two letters, monosyllables with different medial vowels, homonyms, assonance rhymes, consonant rhymes, or

Figure 1. *Representation of the Word Analysis for the Semantic and Phonological Fluency Tasks. Phonetic Transcription with Symbols of the International Phonetic Alphabet*



combined, depending on whether they responded to orthographic (graphemes) or phonological (phonemes) clustering criteria (Gonçalves et al., 2017). The analyses that were used to study the semantic and phonological clustering criteria are described in Figure 1.

Statistical Analysis

All statistical analyses were performed using the Stata (version 15, StataCorp) and InfoStat (version 2020, Infostat Group) softwares. Initially, descriptive statistics (mean and SDs) were calculated for numerical variables and the percentages for categorical ones. In addition, descriptive statistics of the VFTs according to parity were calculated, with distribution and homoscedasticity being studied using the skewness and kurtosis tests for normality and the F test for equality of variances, respectively.

Following Schwartz et al. (2003), the qualitative analysis (i.e., word clustering) was performed using the EFA procedures, CoA and HCA. These multidimensional techniques require the prior preparation of contingency tables, which limit the analysis to the words that occur most frequently (Zheng et al., 2018). In this way, the high probability of intersubject co–occurrence of the productions made it possible to obtain the linguistic profile of the group. The contingency tables cross the evaluated participants (placed in the rows) and the words they produced (placed in the columns), with each table cell indicating whether a word was generated (1) or not (0) to form the word profile.

As dichotomous variables were used, a tetrachoric correlation matrix was estimated from which the EFA was executed. Words with rotated factor loadings greater than 0.30 were included in the clusters (latent variables). For the number of factors to retain, the following parameters were analyzed: the eigenvalue (λ), retaining those with λ greater than 1, based on the Gutman–Kaiser rule (Mavrou, 2015); the Akaike information criterion (AIC), which provides a crude estimator of the expected discrepancy between the model that generates the data and an adjusted model (Cavanaugh, 1997); inspection of the Cattell sedimentation graph to decide the number of factors retained according to the threshold for factor extraction (Rietveld & Van Hout, 2011); and analysis of variance (S2) as an analytical condensation method (Miranda, Rivadero et al., 2020). Subsequently, factorial solutions with orthogonal (varimax) and oblique (promax) rotations were inspected. Finally, factor solutions were analyzed based on the characteristics of parity to detect variability among the women.

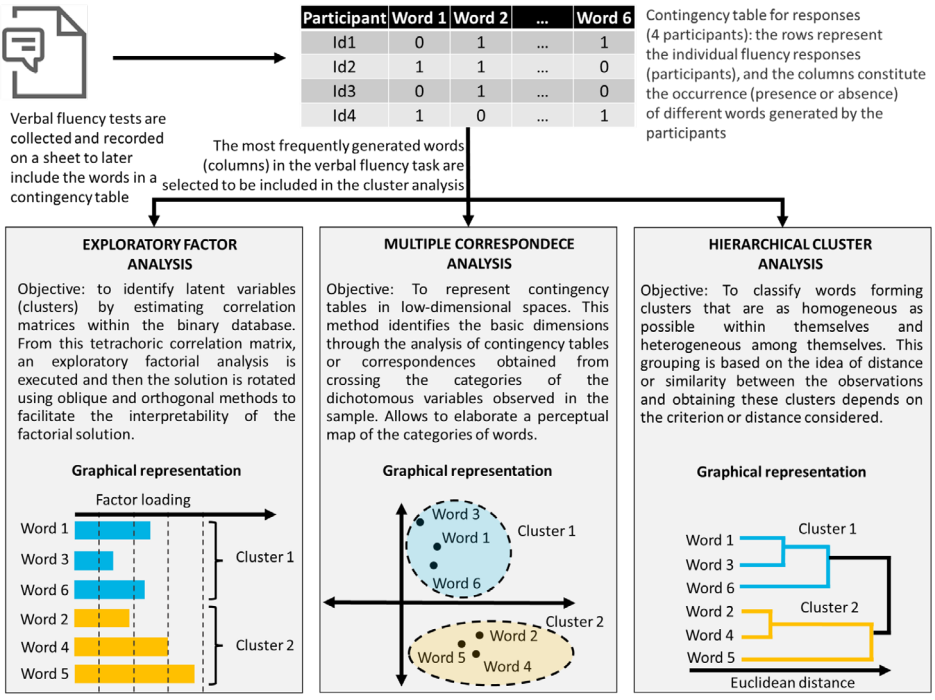
Next, the analysis continued with the execution of traditional word clustering techniques. The CoA is a multivariate method for table exploration which aims to transform the contingency table into graphic maps (correspondence maps). The HCA is a complementary technique to CoA, which allows it to be interpreted more easily (Lebart, 2006). Both procedures are based on estimating the similarity between each word profile. In this sense, if two participants produce similar word

profiles, their profiles will be more likely to be located close on the correspondence map and they will be grouped in the same cluster. A correspondence map makes it possible to visualize the distances between different individuals or groups of individuals as well as the distances between words: the participants who generate similar combinations of words will be located closer, as will the words that are frequently generated in clusters (Schwartz et al., 2003). Consequently, the geometric distances in the correspondence maps will be a direct function of the similarity between the rows or columns in the contingency table.

Multiple linear regression models were calculated to predict the quantitative and qualitative variables of the VFTs based on age, education, parity, and postpartum period, in the equation $Y_i = \beta_0 + \beta_{Age} \times Age + \beta_{Education \geq 12} \times Education + \beta_{multiparity} \times Parity + \beta_{Postpartum \geq 60} \times Postpartum$. Standardized beta coefficients (β), t–values, significance levels, R^2, and F values are reported for each regression model. Subsequently, added–variable plots were constructed for those models with significant results to show the correlations between regressors and dependent variables. $\chi 2$ and φ correlation coefficients were applied to verify the statistical significance of the association between the regressors.

In all the statistical tests carried out, $p < .05$ was considered as the level of statistical significance. The statistical procedures performed for word clustering are summarized in Figure 2.

Figure 2. *Statistical Techniques Used for Word Clustering in Verbal Fluency Tasks*



Results

The sample was composed of 100 puerperal women with a mean age of 29.47 (5.85) years, mostly including women with 12 or more years of formal education (79%). These participants, who were, on average, days 92.31 (52.79) postpartum, included 63% multiparous women. Table 1 summarizes the descriptive statistics of the quantitative and qualitative analyses of the VFTs. The s–VFT (animals) was the one that showed the highest number of correct words (17.73, *SD* = 5.42), total number and mean size of clusters (4.80, *SD* = 2.16, and 2.71, *SD* = 0.68, respectively), switches (8.31, *SD* = 2.73), and total errors (1.59, *SD* = 1.23). On the other hand, the p–VFTs showed a greater number of isolated words. Regarding returning and overlapping, the p–VFT (excluded letter "A") showed the lowest means. In general, intrusions were the most prevalent errors.

Using Exploratory Factor Analysis for Word Clustering

Regarding p–VFT (letter "P"), it was observed that the proximity of the words found in the EFA was reflected by CoA and HCA. Additionally, of the total of 390 words with the letter "P," the 35 most representative (47%) that resulted in seven factors were analyzed considering factor loadings > 0.3 that indicated a good intercorrelation: (a) "paleta," "plato," "planta," and "pijama" ($\lambda = 3.64$, $S^2 = 0.20$, AIC = 1095); (b) "pantalón," "pluma," and "pájaro" ($\lambda = 3.34$, $S^2 = 0.18$, AIC = 1054); (c) "piso," "pato," and "pez" ($\lambda = 2.84$, S2 = 0.15, AIC = 989); (d) "puerta," "pan," and "pelo" ($\lambda = 2.45$, $S^2 = 0.13$, AIC = 919); (e) "pie," "pizza," "palabra," and "pizarrón" ($\lambda = 2.04$, $S^2 = 0.11$, AIC = 919); (f) "papa," "pileta," "paloma," and "pino" ($\lambda = 1.86$, $S^2 = 0.10$, AIC = 907); and (g) "pintura" and "pincel" ($\lambda = 1.73$, $S^2 = 0.09$, AIC = 890). This seven–factor model explained more than 90% of the variability. The most used strategies were "first letters" and "thematic association" (see Figure 3).

On the other hand, the p–VFT (letter "F") and the EFA showed similarities with the CoA and the HCA. A total of 249 different words with letter "F" were evoked, the 25 most representative (52%) were analyzed and the EFA yielded four factors: (a) "flauta," "feliz," "frambuesa," "flan," and "frasco" ($\lambda = 3.26$, $S^2 = 0.30$, AIC = 761); (b) "fruta," "frutilla," "farol," "fósforo," and "funda" ($\lambda = 2.94$, $S^2 = 0.27$, AIC = 679); (c) "fucsia," "fibra," and "fútbol" ($\lambda = 2.40$, $S^2 = 0.23$, AIC = 644); and (d) "fila" and "foco" ($\lambda = 1.72$, $S^2 = 0.20$, AIC = 560). This four–factor model explains more than 80% of the variability. The most used strategies were "first letters" and "thematic association" (see Figure 4).

In the s–VFT (animals), after the analysis of the CoA and HCA, it was observed that the proximity of the words found in the EFA was reflected. Additionally, of the total of 174 evoked animals, the 25 most representative (61%) were analyzed and resulted in five factors: (a) "horse," "cow," "sheep," "bull," and "goat" ($\lambda = 3.30$, S^2

Table 1. Descriptive statistics of the quantitative and qualitative analyses of the semantic and phonological verbal fluency tasks.

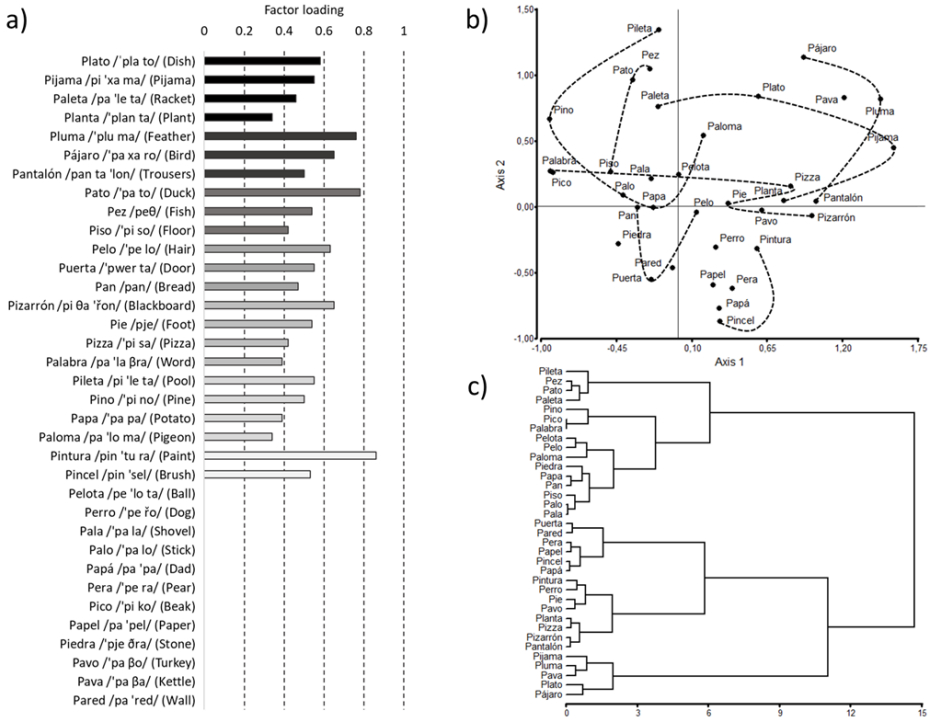
Task	Index	Entire sample			Primiparous			Multiparous			F
		M	*SD*	R	*M*	*SD*	Sk	*M*	*SD*	Sk	
p-VFT (letter "P")	Correct words	13.92	4.24	6-25	13.14	3.70	ns	14.38	4.49	ns	0.68
	Total errors	0.85	1.10	0-5	0.78	0.98	*	0.89	1.17	*	0.70
	Intrusions	0.82	1.06	0-5	0.48	0.69	ns	1.04	1.21	ns	0.33*
	Perseverations	0.26	0.57	0-3	0.28	0.65	*	0.24	0.53	*	1.51
	Number of clusters	3.98	1.83	0-9	4.00	1.72	ns	3.97	1.92	ns	0.80
	Mean cluster size	2.36	0.52	0-4	2.45	0.55	*	2.29	0.50	*	1.19
	Isolated words	5.62	3.07	1-15	4.67	2.71	ns	6.24	3.17	ns	0.73
	Switches	7.75	3.45	3-17	6.71	3.28	ns	8.43	3.43	ns	0.91
	Returns	1.38	1.29	0-5	1.33	1.24	ns	1.41	1.34	ns	0.85
	Overlapping	0.75	0.94	0-4	0.96	0.91	ns	0.62	0.95	*	0.91
p-VFT (letter "F")	Correct words	9.79	3.58	2-21	9.19	3.09	ns	10.14	3.82	ns	0.65
	Total errors	0.63	0.96	0-4	0.41	0.76	*	0.76	1.04	*	0.53
	Intrusions	0.57	0.91	0-4	0.48	0.78	*	0.62	0.98	*	0.64
	Perseverations	0.22	0.50	0-2	0.10	0.41	*	0.29	0.55	*	0.56
	Number of clusters	2.33	1.76	0-11	2.33	1.37	ns	2.32	1.99	*	0.48
	Mean cluster size	0.26	0.68	0-2	1.99	0.85	*	1.88	0.82	*	1.07
	Isolated words	5.08	2.81	0-13	4.42	3.02	ns	5.51	2.61	ns	1.34
	Switches	5.98	2.92	0-15	5.33	2.99	ns	6.41	2.84	ns	1.10
	Returns	0.54	0.77	0-3	0.50	0.66	ns	0.57	0.83	ns	0.62
	Overlapping	0.69	2.14	0-13	0.96	2.69	*	0.51	1.71	*	2.48*
s-VFT (animals)	Correct words	17.73	5.42	1-31	16.11	4.93	ns	18.68	5.50	ns	0.80
	Total errors	1.59	1.23	0-7	1.54	1.24	*	1.62	1.24	ns	1.00
	Intrusions	0.99	0.85	0-3	1.03	0.78	ns	0.96	0.90	ns	0.74
	Perseverations	0.73	1.27	0-7	0.79	1.68	*	0.69	0.95	*	3.12*
	Number of clusters	4.80	2.16	1-10	4.33	2.12	ns	5.11	2.16	ns	0.97
	Mean cluster size	2.71	0.68	2-5	2.62	0.54	*	2.77	0.76	ns	0.51
	Isolated words	4.93	2.74	0-13	5.25	2.91	ns	4.73	2.64	ns	1.21
	Switches	8.31	2.73	4-16	8.25	2.75	ns	8.35	2.75	ns	1.00
	Returns	0.85	0.96	0-3	0.83	1.01	ns	0.86	0.95	ns	1.13
	Overlapping	0.69	1.41	0-6	0.75	1.62	*	0.65	1.27	*	1.62
p-VFT	Correct words	7.68	3.90	0-19	7.03	3.51	ns	8.06	4.09	ns	0.74
(excluded letter "A")	Total errors	1.10	1.31	0-8	1.05	1.29	*	1.13	1.34	*	0.93
	Intrusions	0.96	1.24	0-6	1.00	1.25	ns	0.93	1.25	*	1.00
	Perseverations	0.11	0.31	0-1	0.14	0.35	*	0.09	0.29	*	1.49
	Number of clusters	1.43	1.13	0-5	1.21	0.83	*	1.57	1.28	ns	0.42*
	Mean cluster size	2.03	1.43	0-6	2.02	1.57	ns	2.03	1.35	ns	1.35
	Isolated words	4.28	3.07	0-15	4.38	2.73	ns	4.22	3.31	*	0.68
	Switches	4.72	3.11	0-15	4.67	2.90	ns	4.76	3.28	ns	0.78
	Returns	0.28	0.52	0-2	0.25	0.44	ns	0.30	0.57	*	0.60
	Overlapping	0.20	0.93	0-6	0.04	0.20	*	0.30	1.18	*	0.03*

Note. p-VFT = phonological verbal fluency task; s-VFT = semantic verbal fluency task; *M* = mean; *SD* = standard deviation; R = range; Sk = significance level of the skewness and kurtosis test for normality; *F* = *F* test for equality of variances between groups. *$p < .05$; ns = nonsignificant *p* value.

= 0.26, AIC = 779); (b) “cat,” “parrot,” and “toad” (λ = 2.90, S^2 = 0.23; AIC = 711); (c) “elephant,” “giraffe,” “rhinoceros,” and “crocodile” (λ = 2.70, S^2 = 0.22, AIC = 652); (d) “dolphin,” “whale,” “shark,” and “mouse” (λ = 1.90, S^2 = 0.15, AIC = 592); and (e) “bear,” “lion,” “tiger,” and “cougar” (λ = 1.60, S^2 = 0.12, AIC = 546). This five–factor model explained more than 80% of the variability (see Figure 5).

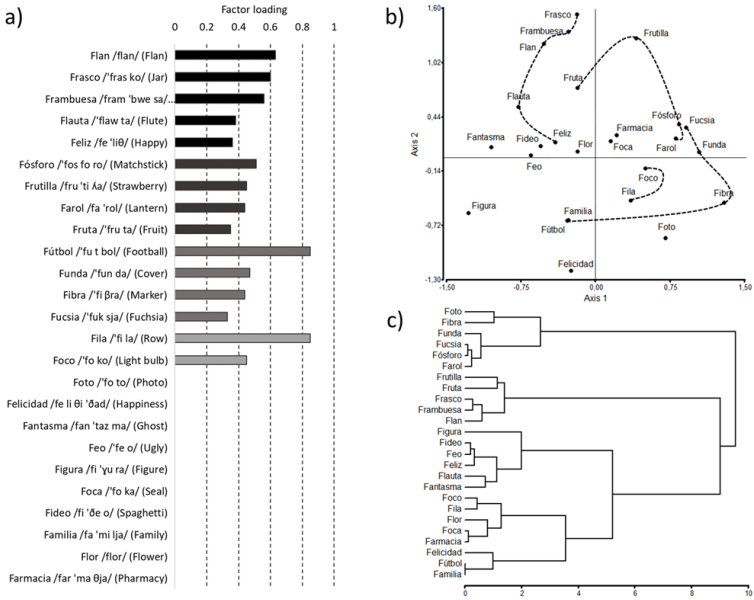
Finally, after the application of CoA and HCA in the p–VFT (excluded letter “A”), the replication of results with respect to the EFA was evidenced. Additionally, a total of 308 different words not containing the letter “A” were evoked, and the 21 most representative (34%) were analyzed. The EFA yielded four factors: (a) “coche,” “bebé,” “luz,” and “televisor” (λ = 3.39, S^2 = 0.34, AIC = 352); (b) “teléfono,” “termo,” and “pez” (λ = 2.47, S^2 = 0.25, AIC = 285); (c) “piso,” “techo,” and “verde” (λ = 2.06, S^2 = 0.20, AIC = 236); and (d) “sillón,” “bolso,” and “rojo” (λ = 1.92, S^2 = 0.19, AIC = 210). This four–factor model explained more than 80% of the variability. The most used strategies were “assonance rhyme” and “thematic association” (see Figure 6).

Figure 3. *Word Clustering Analysis in the Phonological Verbal Fluency Task (Letter “P”)*



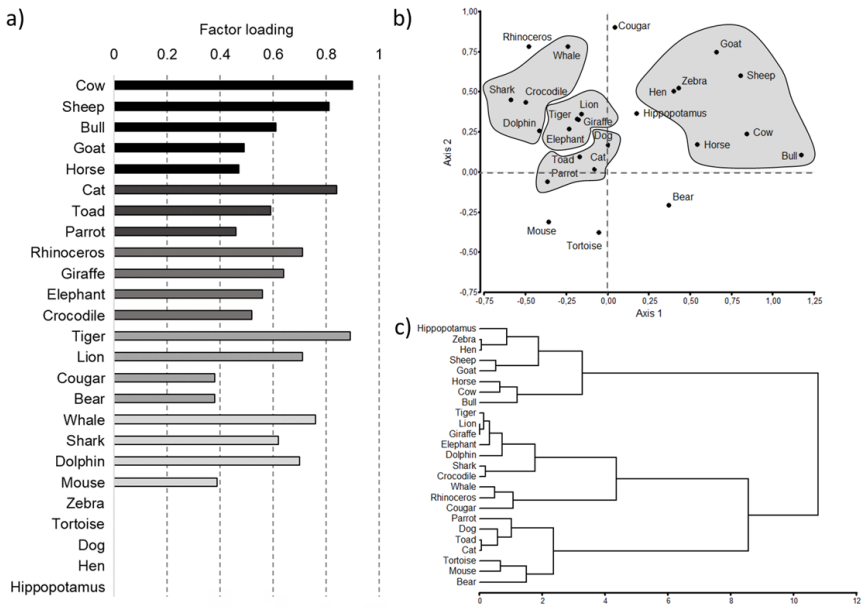
Note. Panel A: factor analysis (promax rotation) Panel B: correspondence analysis. Panel C: dendrogram of the hierarchical cluster analysis (average Euclidean distance). Only the bars of words with factor loadings > 0.30 are shown.

Figure 4. *Word Clustering Analysis in the Phonological Verbal Fluency Task (Letter "F")*



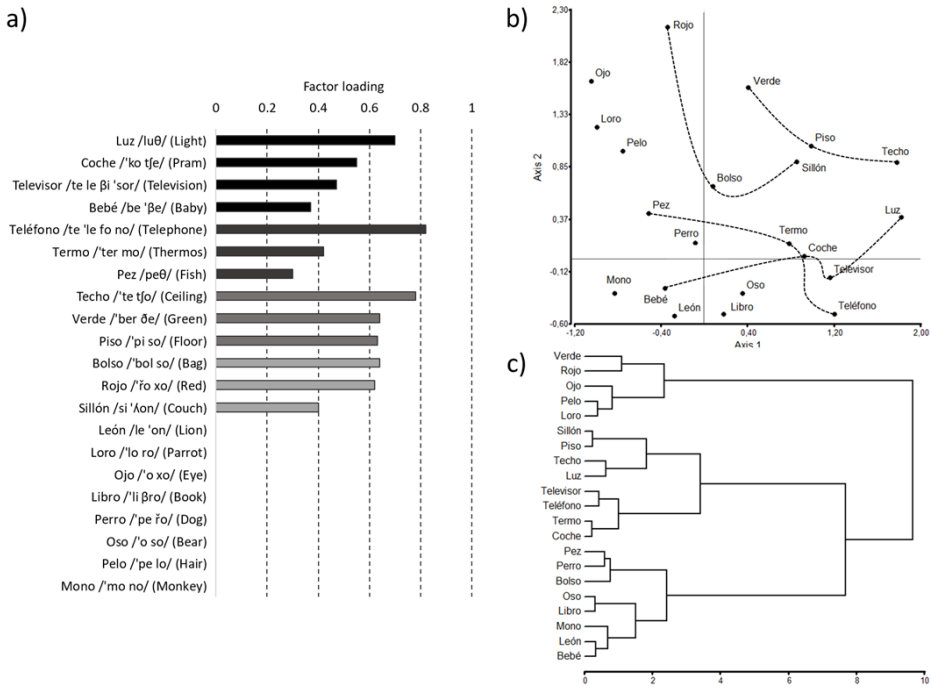
Note. Panel A: factor analysis (promax rotation) Panel B: correspondence analysis. Panel C: dendrogram of the hierarchical cluster analysis (average Euclidean distance). Only the bars of words with factor loadings > 0.30 are shown.

Figure 5. *Word Clustering Analysis in the Phonological Verbal Fluency Task (Animals)*



Note. Panel A: factor analysis (promax rotation). Panel B: correspondence analysis. Panel C: dendrogram of the hierarchical cluster analysis (average Euclidean distance). Only the bars of words with factor loadings > 0.30 are shown.

Figure 6. *Word Clustering Analysis in the Phonological Verbal Fluency Task (Excluded Letter "A")*

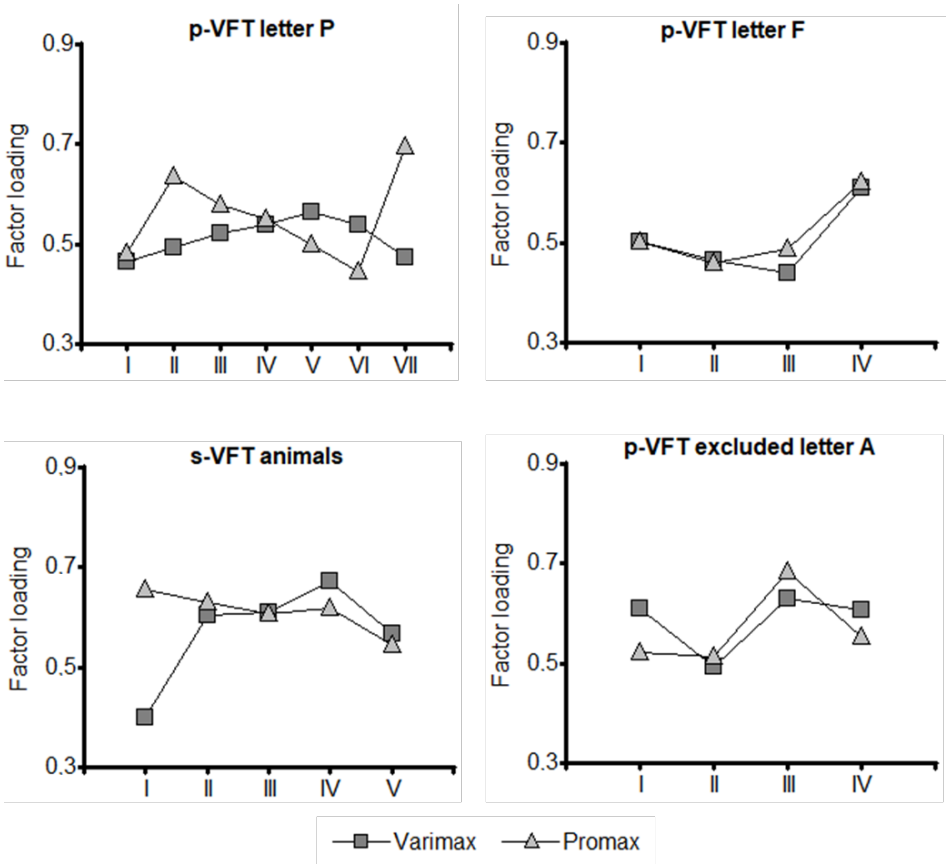


Note. Panel A: factor analysis (promax rotation) Panel B: correspondence analysis. Panel C: dendrogram of the hierarchical cluster analysis (average Euclidean distance). Only the bars of words with factor loadings > 0.30 are shown.

Optimizing the Exploratory Factor Analysis for Word Clustering

It was evaluated whether the type of rotation affects the repeatability of the classification term (i.e., stability) to achieve a robust measurement. Therefore, two different rotation methods were compared to choose the one most congruent with the objectives of the current study. For this, factorial solutions (number of identified factors) and clustering strategies (number of strategies in each factor) were compared according to the varimax (orthogonal) and promax (oblique) rotation methods (see Figure 7 and Table 2). In general, the factor loadings were similar between the rotations, the latter being the one that showed greater stability among the factors. Furthermore, no statistically significant differences were found between the rotation methods (see Figure 7). Regarding the number of words, the promax method included a greater number of words with loads > 0.30. Regarding the identification of clustering strategies, this method was more efficient in detecting the strategies (see Table 2).

Figure 7. *Comparison of the Mean Factor Loading According to the Varimax and Promax Rotations*



Analyzing Differences According to Parity in Word Clustering Through the Exploratory Factor Analysis

To analyze the variability in the factorial structure of semantic and phonological VFTs according to the primiparous and multiparous subsamples, the EFA, CoA and HCA were applied in the s–VFT (animals) and the p–VFT (excluded letter "A"). Regarding primiparous puerperal women in the s–VFT animals, the following clusters were evidenced: (a) "shark," "whale," "dolphin," "mouse," and "cougar" ($\lambda = 4.06$, $S^2 = 0.28$, AIC = 396); (b) "dog," "cat," "tiger," "rhinoceros," "elephant," and "giraffe" ($\lambda = 2.97$, $S^2 = 0.21$, AIC = 392); (c) "sheep," "cow," "bull," and "toad" ($\lambda = 2.72$, $S^2 = 0.19$, AIC = 366); (d) "goat," "horse," "bear," and "hippopotamus" ($\lambda = 2.56$, $S^2 = 0.18$, AIC = 357); and (e) "hen" and "zebra" ($\lambda = 1.8$, $S^2 = 0.12$, AIC = 352).

In contrast, the following clusters were identified in multiparous women: (a) "cat," "dog," "sheep," "horse," "cow," and "bull" ($\lambda = 3.36$, $S^2 = 0.28$, AIC = 150); (b) "giraffe," "hippopotamus," "zebra," "goat," and "hen" ($\lambda = 3.26$, $S^2 = 0.27$,

Table 2. Comparison of the number of factors and clustering strategies in the verbal fluency tasks according to the varimax and promax rotation methods

	p-VFT (letter "P")		p-VFT (letter "F")		s-VFT (animals)		p-VFT (excluded letter "A")	
Factor	VR	PR	VR	PR	VR	PR	VR	PR
Factor 1	6	4	5	5	4	5	3	4
Factor 2	3	3	4	4	5	3	5	3
Factor 3	3	3	4	3	4	4	2	3
Factor 4	3	3	2	2	3	4	3	3
Factor 5	3	4	-	-	4	5	-	-
Factor 6	2	4	-	-	-	-	-	-
Factor 7	3	2	-	-	-	-	-	-
Sum	23	23	15	14	20	21	13	13
Mean	3.29	3.29	3.75	3.50	4.00	4.20	3.25	3.25
Clustering strategies								
Orthographic	12	15	6	8	0	0	1	2
Assonance rhyme	14	14	10	11	0	0	7	6
Consonant rhyme	2	2	0	1	0	1	2	1
Thematic	5	7	4	6	6	6	4	4
Sum	33	38	20	26	6	7	14	13
Mean	8.25	9.50	5.00	6.50	1.50	1.75	3.50	3.25

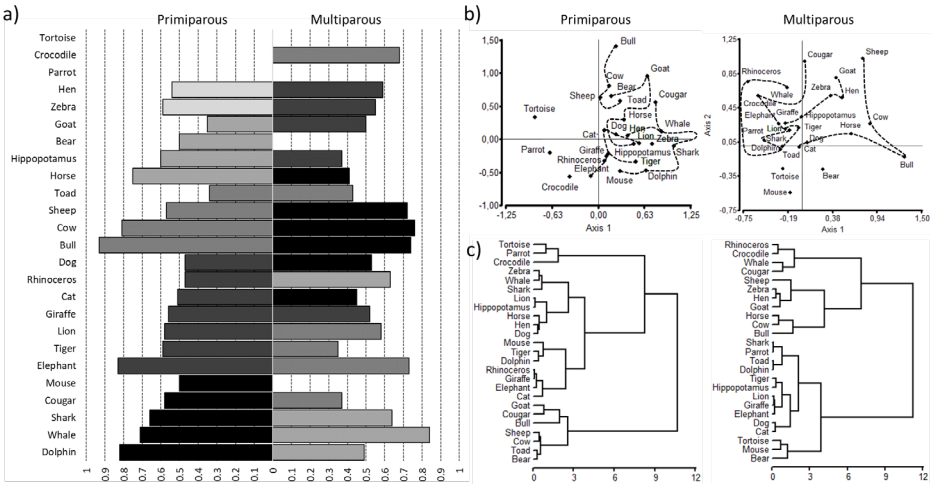
Note. p-VFT = phonological verbal fluency task; s-VFT = semantic verbal fluency task; VR = varimax rotation; PR = promax rotation.

AIC = 134); (c) "toad," "crocodile," "elephant," "lion," "tiger," and "cougar" (λ = 2.99, S^2 = 0.25, AIC = 117); (d) "dolphin," "shark," "whale," and "rhinoceros" (λ = 2.23, S^2 = 0,18, AIC = 958). Summing up, statistically significant factor solutions (with high factor loadings) clearly showed clustering differences on semantic tasks, as shown in Figure 8. Also, Table 3 displays the association strategies of each factor in the s–VFT (animals) in primiparous and multiparous puerperal women. Moreover, multiparous women always evinced a clustering strategy and initiated with more common animals, then mentioning other, more atypical ones. This indicated an efficient strategy of responses with increasing difficulty.

Regarding the p–VFT (excluded letter "A"), the following clusters were evidenced in the case of primiparous women: (a) "sillón," "televisor," "teléfono," "techo," "luz," and "oso" (λ = 4.04, S^2 = 0.36, AIC = 223); (b) "bolso," "piso," "coche," and "termo" (λ = 2.81, S^2 = 0.25, AIC = 221); (c) "león," "pelo," and "bebé" (λ = 2.39, S^2 = 0.21, AIC = 197), and (d) "perro" and "ojo" (λ = 1.97, S^2 = 0.17, AIC = 188).

Finally, the following clusters were evidenced among multiparous women: (a) "luz," "teléfono," "televisor," "termo," and "coche" (λ = 3.41, S^2 = 0.30, AIC = 401); (b) "techo," "rojo," and "verde" (λ = 2.97, S^2 = 0.26, AIC = 370); (c) "sillón," "bolso," "ojo," and "perro" (λ = 2.46, S2 = 0.21, AIC = 328); and (d) "piso" and "pelo" (λ = 2.35, S^2 = 0.21, AIC = 304, see Figure 9). Table 4 expresses the association strategies of each factor in the p–VFT (excluded letter "A") in primiparous and multiparous postpartum women.

Figure 8. *Word Clustering Analysis in the Semantic Verbal Fluency Task (Animals) in Primiparous (n = 37) and Multiparous (n = 63) Postpartum Women*



Note. Panel A: factor analysis (promax rotation). Panel B: correspondence analysis. Panel C: dendrogram of the hierarchical cluster analysis (average Euclidean distance). Only the bars of words with factor loadings > 0.30 are shown.

Table 3. Number of words in the factor solution of semantic verbal fluency task animals according to postpartum women's parity

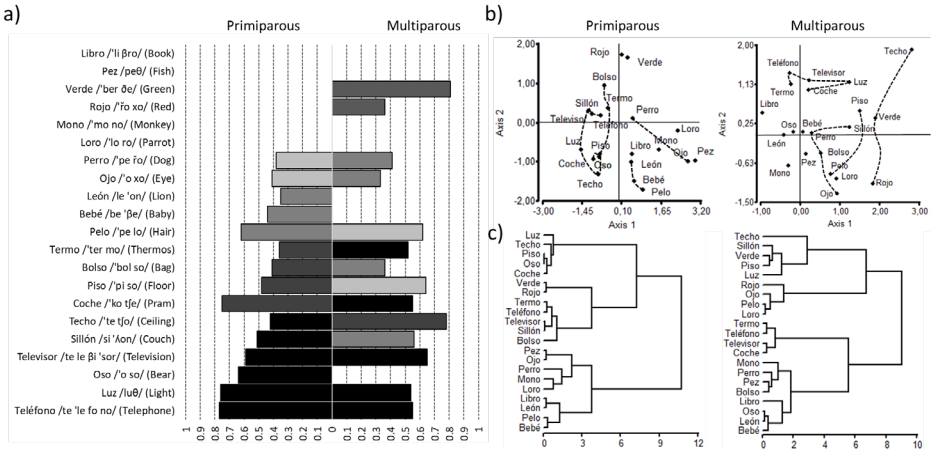
	Primiparous (*n* = 37)		Multiparous (*n* = 63)	
Factor	Thematic strategy	*n* words	Thematic strategy	*n* words
1	jungle and sea animals	5	farm animals	6
2	house and jungle animals	6	farm and jungle animals	5
3	farm animals	4	jungle animals	6
4	farm and jungle animals	4	jungle and sea animals	4
5	nonevident clustering strategy	2		

Assessing the Effects of Reproductive History on Verbal Fluency

Table 5 shows the multivariate regression models for the quantitative and qualitative analysis of the VFTs according to educational level, age, parity, and postpartum time. The main variable that influenced verbal fluency was educational level, which predicted numbers of correct words, clusters, switches, and returns. Second, multiparity was associated with a higher number of correct words in VFTs. Regarding the variables of the qualitative analysis, parity was associated with intrusions, isolated words, and switches (for the VFT [letter "P"]), number of clusters (for the VFT [excluded letter "A"]), and marginally with switches (for the VFT [letter "F"]) and number of clusters (for the s–VFT [animals]). Description of the multivariate regression models and added–variable plots are provided in the Appendix.

To detect associations among regressor variables, the $\chi 2$ test and φ correlation coefficients were calculated. No statistically significant associations were found

Figure 9. *Word Clustering Analysis in the p-VFT (Excluded Letter "A") in Primiparous (n = 37) and Multiparous (n = 63) Postpartum Women*



Note. Panel A: factor analysis (promax rotation). Panel B: correspondence analysis. Panel C: dendrogram of the hierarchical cluster analysis (average Euclidean distance). Only the bars of words with factor loadings > 0.30 are shown.

Table 4. Number of words and strategies in the factor solution of p-VFT (excluded letter "A") according to postpartum women's parity

	Parity	
Factors	Primiparous (n = 37)	Multiparous (n = 63)
1	6	5
2	4	3
3	3	4
4	2	2
Total	15	14
Clustering strategies		
Orthographic	2	3
Assonance rhyme	6	8
Consonant rhyme	0	2
Thematic	2	2
Total	10	15

between parity and age, χ^2 (1, N = 100) = 0.002, p = .9639, φ = –0.01, educational level, χ^2 (1, N = 100) = 3.675, p = .0522, φ = –0.19, or postpartum period, χ^2 (1, N= 100) = 1.969, p = .1606, φ = 0.14. Postpartum period was also not associated with age, χ^2 (1, N = 100) = 0.005, p = .9441, φ = 0.01 or educational level, χ^2 (1, N = 100) = 1.44, p = .2301, φ = 0.12. Similarly, age and educational level were not associated, χ^2 (1, N = 100) = 0.06, p = .8095, φ = 0.02.

Table 5. Multivariate regression models among measures of the verbal fluency tasks and age, education, parity, and postpartum period in postpartum women

p-VFT (letter "P")	Corrects	Errors	Intr	Pers	NC	MCS	IW	Sw	R	O
Age[a]	β = −0.05	β = −0.08	β = −0.20	β = −0.04	β = −0.11	β = −0.15	β = 0.03	β = −0.07	β = −0.10	β = 0.10
	p = .0578	*p* =.423	*p* = .083	*p* = .771	*p* = .394	*p* = .275	*p* = .835	*p* = .597	*p* = .454	*p* = .468
Educational level[b]	**β = 0.44**	**β = 0.22**	**β = 0.34**	β = 0.15	**β = 0.47**	β = 0.04	β = 0.13	**β = 0.28**	**β = 0.32**	β = 0.22
	***p* < .001**	***p* = .047**	***p* = .007**	*p* = .248	***p* < .001**	*p* = .766	*p* = .331	***p* = .036**	***p* = .020**	*p* = .111
Parity[c]	**β = 0.24**	β = 0.11	**β = 0.37**	β = 0.01	β = 0.12	β = −0.11	**β = 0.28**	**β = 0.33**	β = 0.12	β = -0.15
	***p* = .015**	*p* = .324	***p* = .002**	*p* = .248	*p* = .340	*p* = .425	**p = .045**	***p* = .016**	*p* = .368	*p* = .270
Postpartum period[d]	β = 0.04	β = 0.04	β = 0.02	β = 0.04	β = −0.09	β = 0.18	β = 0.08	β = 0.06	β = 0.00	β = −0.21
	p = .673	*p* = .722	*p* = .879	*p* = .739	*p* = .448	*p* = .171	*p* = .527	*p* = .650	*p* = .986	*p* = .108
p-VFT (letter "F")										
Age[a]	β = −0.08	β = −0.04	β = −0.18	β = −0.02	β = 0.01	β = −0.11	β = 0.10	β = −0.18	β = 0.00	β = 0.20
	p = .394	*p* = .669	*p* = .131	*p* = .906	*p* = .971	*p* = .418	*p* = .474	*p* = .190	*p* = .990	*p* = .142
Educational level[b]	**β = 0.30**	**β = 0.21**	β = 0.19	β = 0.00	β = 0.24	β = 0.25	β = 0.06	β = 0.21	β = 0.22	β = −0.20
	***p* = .005**	***p* = .048**	*p* = .136	*p* = .988	*p* = .091	*p* = .068	*p* = .688	*p* = .124	*p* = .121	*p* = .147
Parity[c]	**β = 0.20**	**β = 0.22**	β = 0.15	β = 0.18	β = 0.05	β = 0.02	β = 0.23	β = 0.27	β = 0.09	β = −0.19
	***p* = .052**	***p* = .033**	*p* = .219	*p* = .151	*p* = .714	*p* = .900	*p* = .107	*p* = .053	*p* = .504	*p* = .169
Postpartum period[d]	β = 0.13	β = 0.18	β = 0.13	β = 0.16	β = 0.05	β = 0.14	β = 0.04	β = 0.04	β = 0.04	β = 0.16
	p = .210	*p* = .074	*p* = .292	*p* = .200	*p* = .707	*p* = .304	*p* = .765	*p* = .763	*p* = .791	*p* = .219
s-VFT (animals)										
Age[a]	β = 0.10	β = −0.01	β = −0.21	β = 0.00	β = 0.19	β = −0.23	β = 0.08	β = 0.19	**β = 0.29**	β = 0.18
	p = .213	*p* = .958	*p* = .086	*p* = .981	*p* = .103	*p* = .083	*p* = .554	*p* = .150	***p* = .030**	*p* = .206
Educational level[b]	**β = 0.49**	β = 0.09	β = 0.16	β = −0.07	**β = 0.37**	β = 0.27	β = 0.11	**β = 0.32**	β = −0.02	β = 0.03
	***p* < .001**	*p* = .435	*p* = .214	*p* = .616	***p* = .003**	*p* = .054	*p* = .420	***p* = .018**	*p* = .882	*p* = .821
Parity[c]	**β = 0.29**	β = 0.04	β = 0.03	β = −0.06	β = 0.22	β = 0.12	β = −0.09	β = 0.05	β = −0.05	β = −0.07
	***p* < .001**	*p* = .690	*p* = .826	*p* = .660	*p* = .067	*p* = .397	*p* = .542	*p* = .696	*p* = .713	*p* = .642
Postpartum period[d]	**β = 0.19**	β = 0.11	β = 0.20	β = 0.09	**β = 0.25**	β = −0.01	β = −0.08	β = 0.10	β = 0.23	β = 0.12
	***p* = .024**	*p* = .295	*p* = .105	*p* = .466	***p* = .037**	*p* = .949	*p* = .583	*p* = .434	*p* = .087	*p* = .386
p-VFT (excluded letter "A")										
Age[a]	β = −0.09	β = 0.10	β = 0.01	β = −0.04	**β = −0.32**	β = −0.23	β = 0.15	β = 0.04	β = −0.16	β = −0.14
	p = .356	*p* = .337	*p* = .914	*p* = .748	***p* = .011**	*p* = .083	*p* = .252	*p* = .754	*p* = .232	*p* = .311
Educational level[b]	**β = 0.42**	β = 0.08	β = 0.00	β = 0.07	**β = 0.32**	β = 0.27	**β = 0.27**	**β = 0.35**	β = 0.20	β = 0.16
	***p* < .000**	*p* = .451	*p* = .977	*p* = .619	***p* = .013**	*p* = .054	***p* = .048**	***p* = .012**	*p* = .148	*p* = .244
Parity[c]	**β = 0.22**	β = 0.02	β = −0.03	β = −0.06	**β = 0.30**	β = 0.12	β = 0.00	β = 0.08	β = 0.13	β = 0.20
	***p* = .022**	*p* = .885	*p* = .804	*p* = .652	***p* = .019**	*p* = .397	*p* = .979	*p* = .530	*p* = .365	*p* = .144
Postpartum period[d]	β = 0.10	β = 0.09	β = 0.15	β = 0.12	β = 0.16	β = −0.01	β = −0.06	β = −0.01	β = 0.02	β = 0.10
	p = .305	*p* = .378	*p* = .250	*p* = .360	*p* = .197	*p* = .949	*p* = .647	*p* = .917	*p* = .901	*p* = .476

Note. a ≥ 35 versus < 35 years-old; b ≥ 12 versus < 12 years of formal education; c multiparity versus primiparity; d ≥ 60 versus < 60 days postpartum. Int = intrusions; Pers = perseverations; NC = number of clusters; MCS = mean cluster size; IW = isolated words; Sw = switches; R = returns; O = overlapping. Values are expressed as adjusted beta coefficients (β) with the corresponding *p* value

Discussion

The study of word production strategies in VFTs is increasingly garnering interest in neuropsychology, and qualitative analysis has been proposed as a promising method for the study of human cognition (Gonçalves et al., 2017; Sunila et al., 2018). Our hypothesis was confirmed because the application of the EFA allowed for optimizing the study of semantic and phonological verbal fluency, which also showed to be influenced by women's parity. Although the usefulness of the EFA has been confirmed in other disciplines, conceptual and methodological criteria should be considered to achieve an optimal adaptation to neurolinguistics, as suggested by Mavrou (2015) and to avoid technically inappropriate EFAs with misleading results (Kline, 1994). Consequently, here, a solution was sought that would satisfy mathematical criteria and lead to an adequate interpretation (conceptually plausible, easily interpretable, and replicable), which could be applied in future longitudinal investigations that analyze linguistic production through VFTs. Although the sample size did not meet the criteria of Arrindell and Van der Ende (1985), there is evidence on the value and applicability of EFA in small samples (de Winter et al., 2009), even with as few as 50 cases (Hair et al., 2010).

As research is needed to increase understanding of how rotation influences factor analytical conclusions (Sass, 2010), we compared the varimax and promax rotation methods. It should be noted that although the promax rotation showed higher factorial loads and greater stability between the factors, no marked differences were evidenced in composition and interpretability across rotation methods. Barbero García et al. (2011) propose the use of an orthogonal model in EFA since the underlying factor structure is unknown, while the oblique model is typical of confirmatory factor analysis. However, oblique rotations (e.g., promax) are probably the best option, especially when a conceptual association is assumed between the latent variables under examination (Fabrigar & Wegener, 2012), as the case when a greater neuropsychological significance of the distinguished factors is sought (Pérez & Medrano, 2010). According to the evidence, oblique rotations allow for obtaining precise, simple, reproducible, and more realistic solutions, which outperform orthogonal rotations (Beavers et al., 2013). If there is no correlation between the factors, the oblique and orthogonal rotations will provide similar estimators. However, if there is a correlation, an oblique rotation will reveal it (Fabrigar & Wegener, 2012). Furthermore, this was confirmed in the current study, where the best solution was the oblique method. There was a significant finding in relation to the number of clustering strategies identified through the promax rotation, mainly orthographic and thematic in the p–VFTs.

In general, in the s–VFT (animals), there was more word production, errors, and organizational strategies with respect to the p–VFT, in accordance with Azuma (2004). This may be because semantic evocation is simpler than phonological, since retrieved words are within facilitated associations, while phonological

evocationsinvolve constructed associations (Marino et al., 2011b). In the semantically performed clusters, jungle animals predominated. As Fumagalli et al. (2018) explain, lexical access and selection follow certain patterns that allow for examining the organization of the semantic memory. In this sense, the items included in the semantic subcategory of jungle animals correspond to the most frequent and typical lexical concepts of the sample, and the absence of clusters such as desert animals, furry animals and cargo suggests the influence of culture on familiarity with the words that make up each category (Aizpurua & Lizaso, 2015). Clustering words that share the first two letters was the most used method in the three p–VFTs, implying an orthographic criterion, which agrees the results by Nieto et al. (2008).

Existing evidence suggests that performance in VFTs can be affected by educational level (Jebahi et al., 2020), which was confirmed by our study, since this was the variable that most influenced the verbal fluency indices. Other studies agree that education expands the mental lexicon size and positively affects the access and retrieval of words (Nogueira et al., 2016; Wilson et al., 2016). In addition, it has been shown that executive functions are globally improved by educational level (Miranda, Franchetto Sierra et al., 2020). Literacy favors word production strategies in VFTs, as it enhances the control and maintenance of the lexical and phonological organization necessary to plan and execute clustering, switching, production of isolated words, returning, and overlapping (Chiossi et al., 2016; Gonzales Da Silva et al, 2004; Pereira et al., 2018).

Regarding reproductive factors, differences between primiparous and multiparous women were consistent with previous results (Rivadero, 2018), including the association between parity and postpartum mental state (Miranda, Cortez et al., 2021). This provides evidence on the changes in executive functions that occur during postpartum, such as verbal memory and semantic access (Henry & Sherwin, 2012). The analysis showed that multiparous women produced more correct words than primiparous women. Although the best multiparous performance occurred in the four PFVs, this predominated in the semantic ones. This can also be explained by the executive demands that phonological tests imply (Marino et al., 2011a), with greater executive difficulties being faced by women during the puerperium (Zheng et. al., 2018). On the other hand, the significant differences in the semantic animal clusters could be due to the faster recovery of the cognitive state typical of multiparity (Parsons et al., 2004).

While the s–VFT Animals was associated with the organizational strategies linked to the lexical–associative component of verbal fluency, the p–VFTs found differences in errors and in organizational strategies linked to the executive component of verbal fluency. In both cases, the variations respond to the main components of each of the tasks (Fumagalli et al., 2018). Semantic variations indicate involvement of the temporal lobe (associative) and phonological variations of the frontal lobe (executive) in neuropsychology (Troyer et al., 1998). Thus, the puerperium is associated both with variations in the associative and

executive processes involved in the production of words (Carrizo et al., 2020). The semantic reorganization that occurs during the puerperium and as a function of parity is linked to the neuroadaptive mechanisms consequent to reproductive experiences (Parsons et al., 2004). The term baby brain or maternal brain is commonly used to describe the cognitive changes induced by the reproductive experiences of pregnancy and the puerperium (Zhao et al., 2019; Kim et al., 2018). A growing body of neuroscientific literature has provided evidence on the long–term changes in women's central nervous system structures and functions that occur during reproductive experiences (Miranda, Cortez et al., 2021; Glynn, 2010; Kinsley & Lambert, 2008; Pawluski et al., 2017; Gatewood et al., 2005). Hoekzema et al. (2017) showed that primiparous women experience a symmetrical pattern of reduction in the volume of gray material during pregnancy, specifically in anterior and posterior medial cortical areas, and lateral areas of the prefrontal and temporal cortex. Although there is still no consensus on what are the specific aspects of cognitive functioning that vary, and how they occur (Glynn, 2010), as a whole, research suggests that the maternal brain exhibits processes of neuroplasticity and neurogenesis, which serve the establishment of behavioral and cognitive changes to meet the physical and emotional demands inherent to motherhood (Barha & Galea, 2017, Leuner & Sabihi, 2016).

From an adaptive perspective, it is argued that the cognitive reorganization that arises after the reproductive experiences of pregnancy and puerperium enables better performance in certain skills that can fulfill a protective function for the fetus or neonate (Anderson & Rutherford, 2012). Pereira and Ferreira (2016) explain that cognitive functions are crucial for motherhood because they allow us to perceive and interpret the needs of the offspring, as well as to regulate maternal behavior to meet them. In this sense, mothers from different species tend to perform better than nulliparous females in tasks that involve cognitive functions of attention, cognitive flexibility, working memory and spatial learning (Carrizo et al., 2020). Additionally, women who breastfeed exhibit cognitive benefits after the age of 50 with better performance on a series of neuropsychological tests. Thus, cognition is promoted with effects felt beyond the puerperium (Fox et al., 2021). These neuroadaptive processes in the reproductive life of a woman can explain the results found in the multivariate linear regression models of the present study. In addition to having found that multiparity was associated with a greater number of correct words in the four FVTs, significant associations were also obtained for the qualitative measures (cluster size, switches, and isolated words) and with errors. In other words, multiparous women showed better performance in the tests as they used more efficient executive strategies to achieve a greater number of correct words. It also implied in turn a greater probability of making mistakes, since more complex executive processes are involved (for example, switches, cluster sizes, processing speed). Various studies have reported that reproductive history has a protective effect on white (e.g., corpus callosum) and gray matter (e.g., cortical thickness) later in life, with better cognitive outcomes

(Voldsbekk et al., 2021; Orchard et al., 2020).

Some limitations need to be addressed. As previously explained, although the sample size may seem small for the execution of the EFA, the exploratory nature of the work justifies its applicability. Likewise, we suggest that future research apply the EFA for the study of VFTs in larger populations. Another factor to consider is the study design, which is cross–sectional in nature. Although we adjusted for a variety of individual characteristics and used different statistical approaches, the cross–sectional nature limits the inference on causality among variables. A longitudinal study design needs to be pursued to clarify the reproductive history effect on the VFTs. Despite these limitations, our study may be referred to as a first study that aimed at evaluating a multivariate technique such as EFA for the identification of word clusters and exploring the effects of reproductive history on quantitative and qualitative measures of VFTs. Thus, these findings make significant contributions to the literature on neuropsychology and language, and especially to the study of women's mental health.

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Conflict of Interest Disclosure

The Authors have no conflicts of interest to disclose.

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Research Ethics Statement

Research Ethics Statement: All procedures were carried out in accordance with the Declaration of Helsinki and current laws. The work was approved by the Health Research Ethics Committee of the National Clinics Hospital belonging to the National University of Cordoba (registry numbers: REPIS-5554 and RENISIS001262).

Authorship Details

Paula Eugenia Barral: research concept and design, collection and/or assembly of data, data analysis and interpretation, writing the article, critical revision of the article, final approval of the article.

Augustin Ramiro Miranda: research concept and design, collection and/or assembly of data, data analysis and interpretation, writing the article, critical revision of the article, final approval of the article.

Mariela Valentina Cortez: data analysis and interpretation, writing the article, critical revision of the article, final approval of the article.

Ana Veronica Scotta: data analysis and interpretation, writing the article, critical revision of the article, final approval of the article.

Elio Andrés Soria: research concept and design, collection and/or assembly of data, data analysis and interpretation, writing the article, critical revision of the article, final approval of the article.

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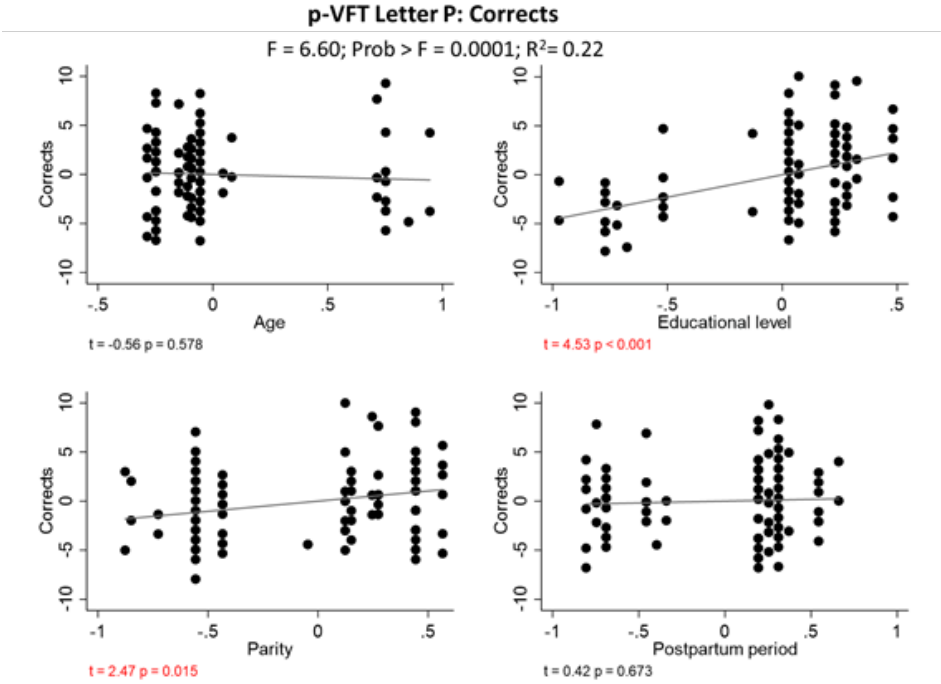
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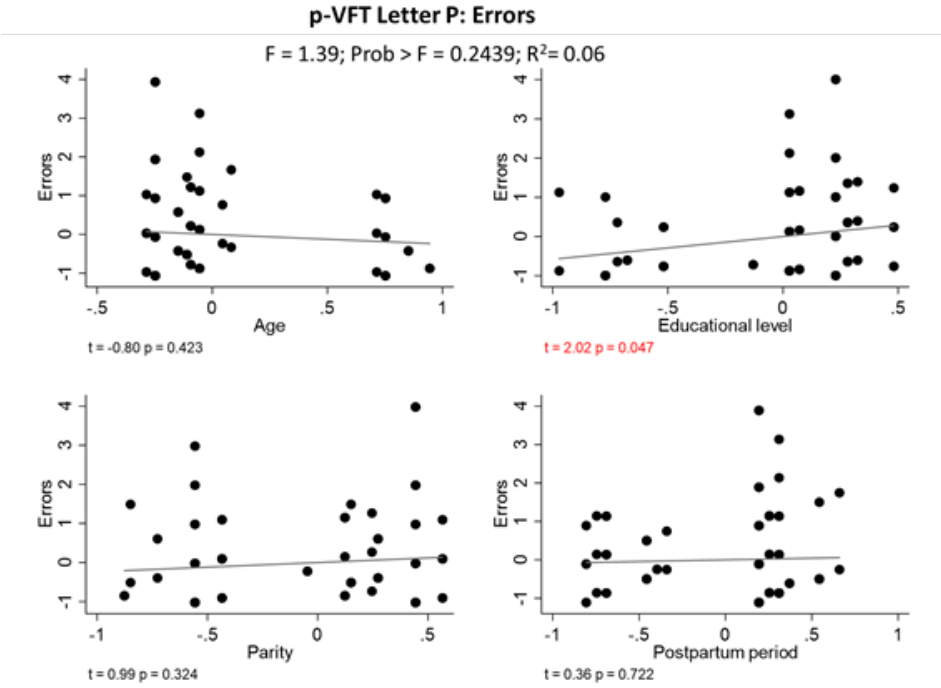
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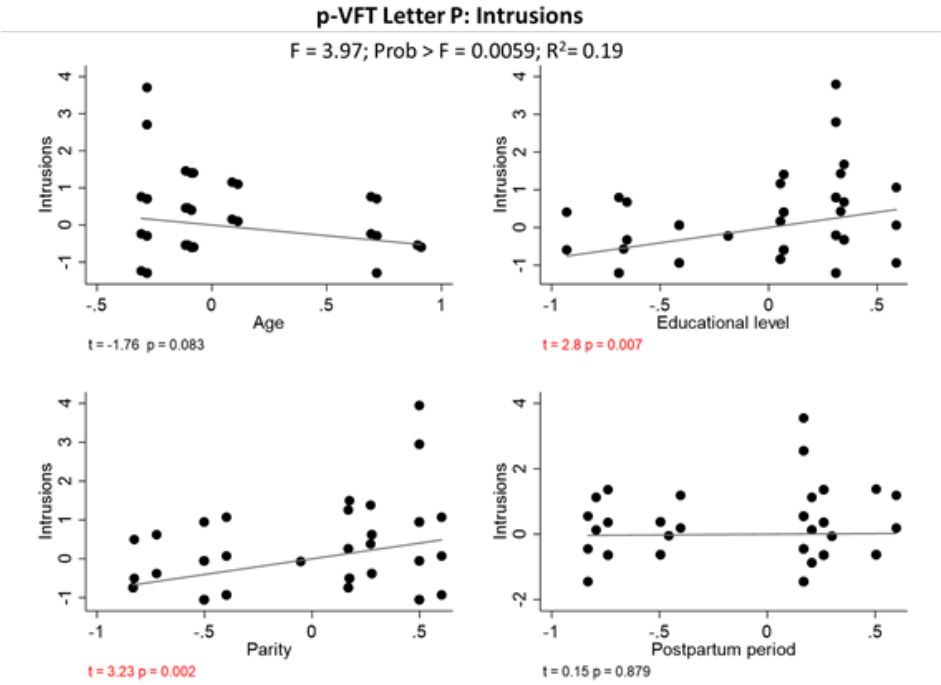
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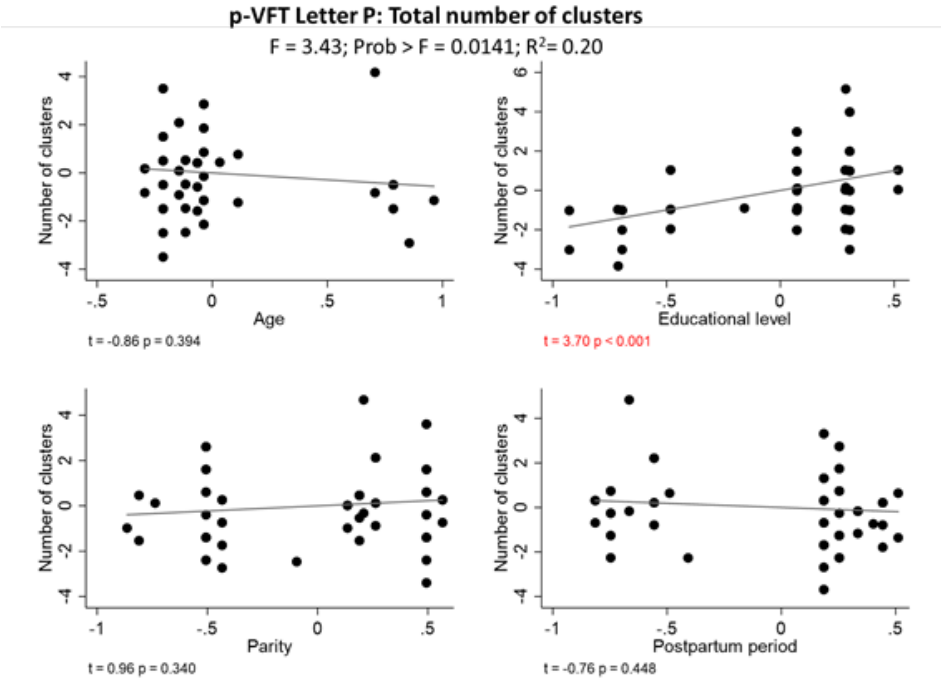
Appendix: Description of the multivariate regression models and added-variable plots

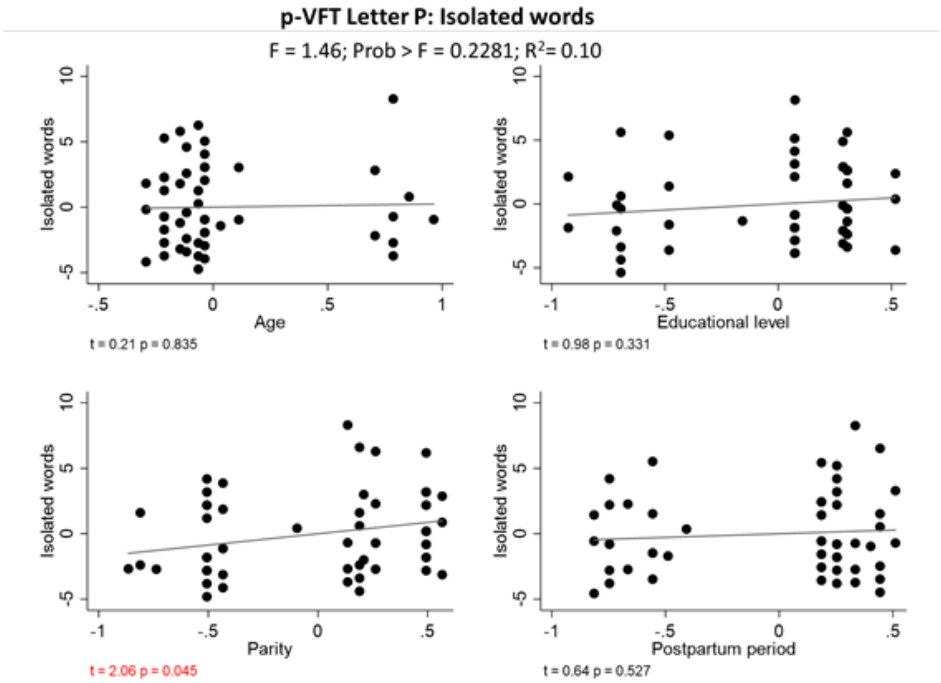
Regressors were categorized as: Age = ≥ 35 vs < 35 years-old; educational level = ≥ 12 vs < 12 years of formal education; parity = mutiparity vs primiparity; postpartum period = ≥ 60 vs < 60 days of postpartum; p-VFT = phonological verbal fluency task; s-VFT = semantic verbal fluency task.

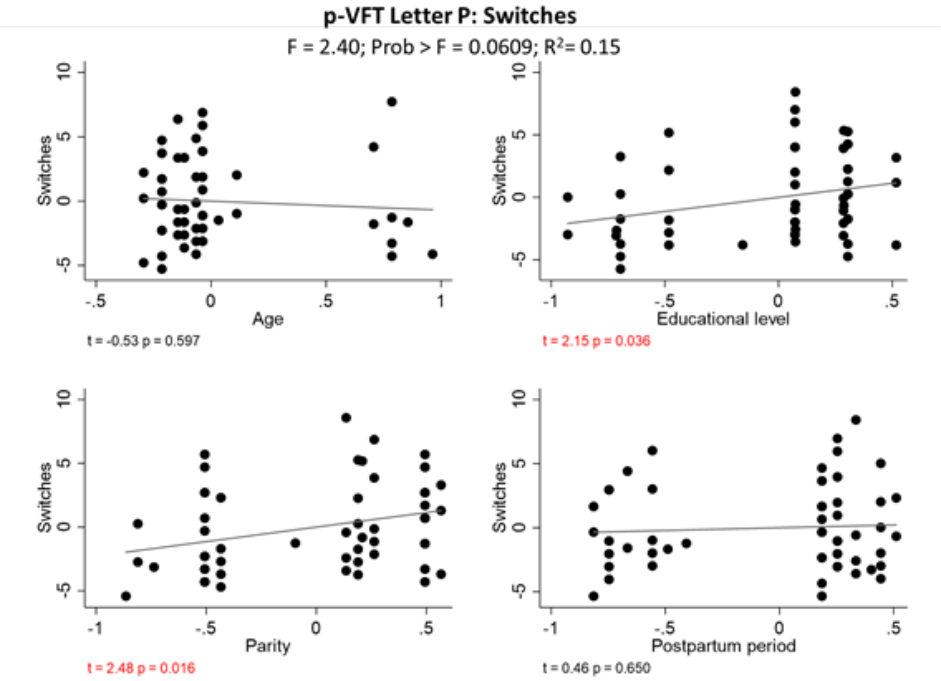


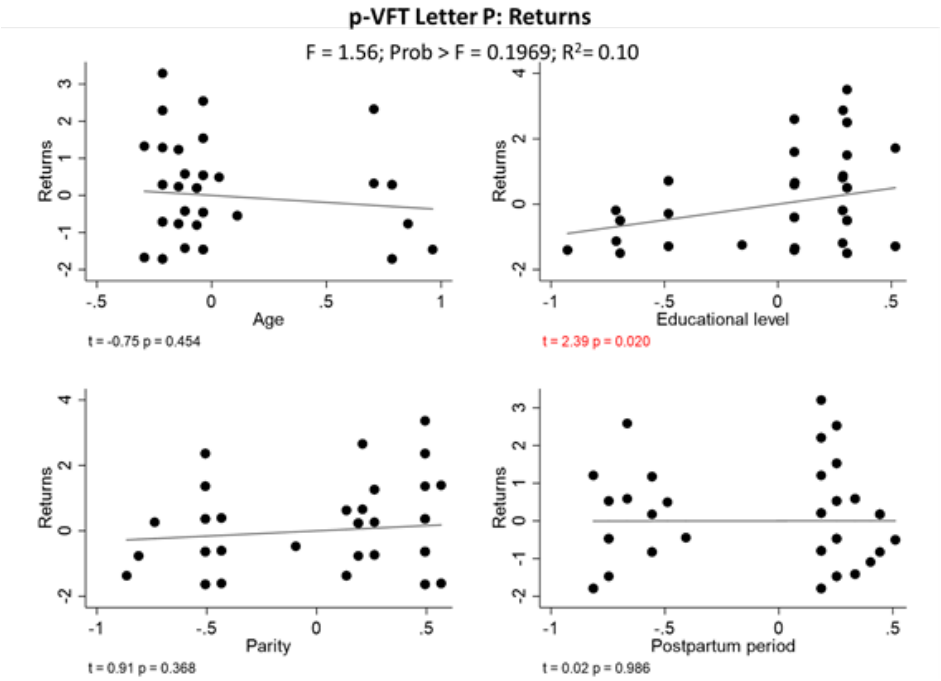

p-VFT Letter P: Errors
F = 1.39; Prob > F = 0.2439; R²= 0.06
Errors
Age
t = -0.80 p = 0.423
Educational level
t = 2.02 p = 0.047
Parity
t = 0.99 p = 0.324
Postpartum period
t = 0.36 p = 0.722

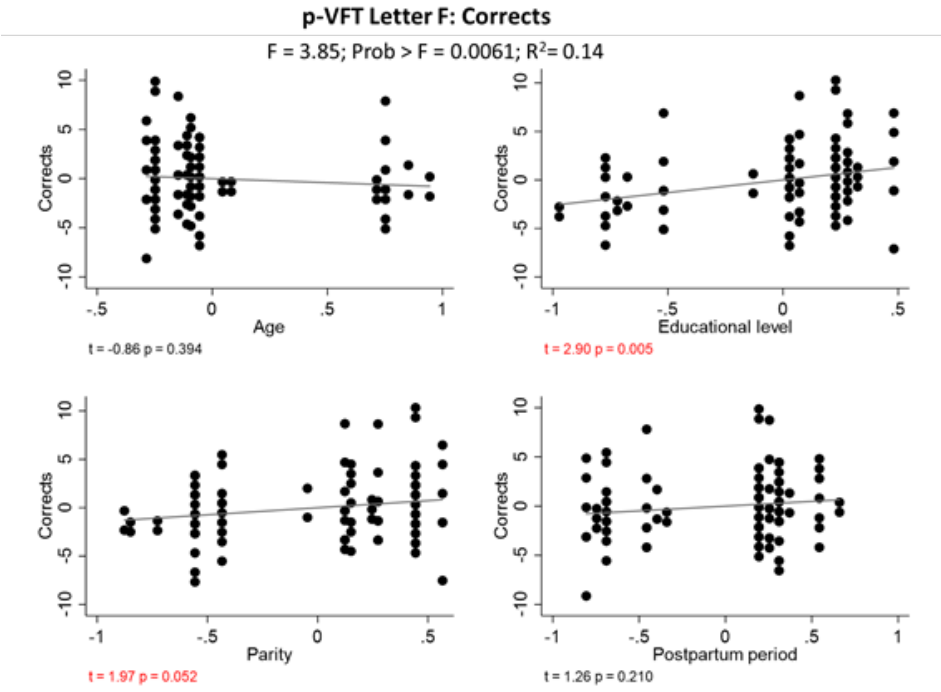

p-VFT Letter P: Intrusions
F = 3.97; Prob > F = 0.0059; R²= 0.19
Intrusions
Age
t = -1.76 p = 0.083
Educational level
t = 2.8 p = 0.007
Parity
t = 3.23 p = 0.002
Postpartum period
t = 0.15 p = 0.879

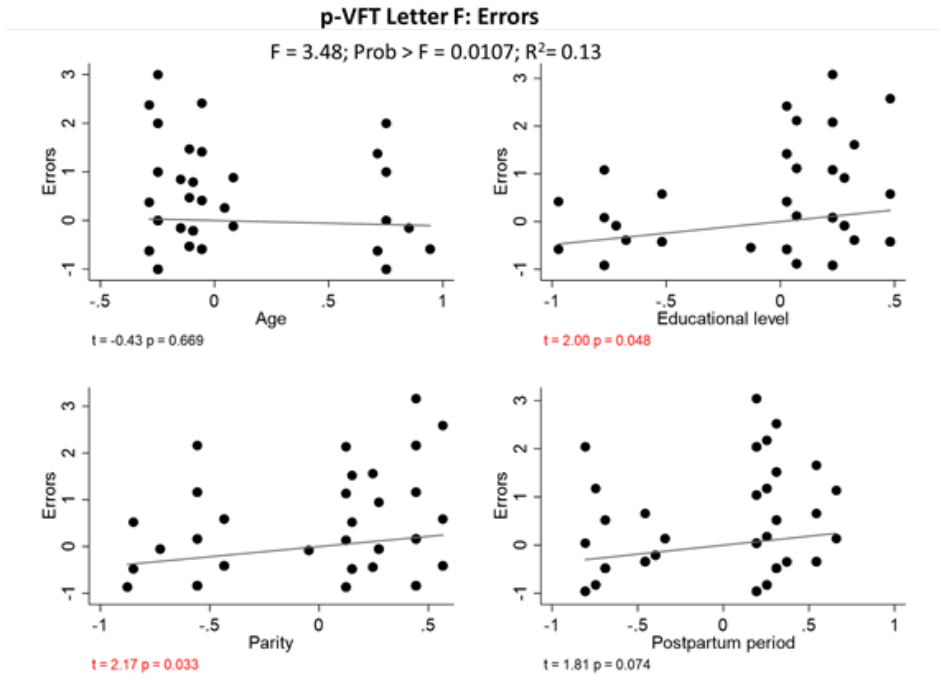

p-VFT Letter P: Total number of clusters
F = 3.43; Prob > F = 0.0141; R²= 0.20
Number of clusters
Age
t = -0.86 p = 0.394
Educational level
t = 3.70 p < 0.001
Parity
t = 0.96 p = 0.340
Postpartum period
t = -0.76 p = 0.448

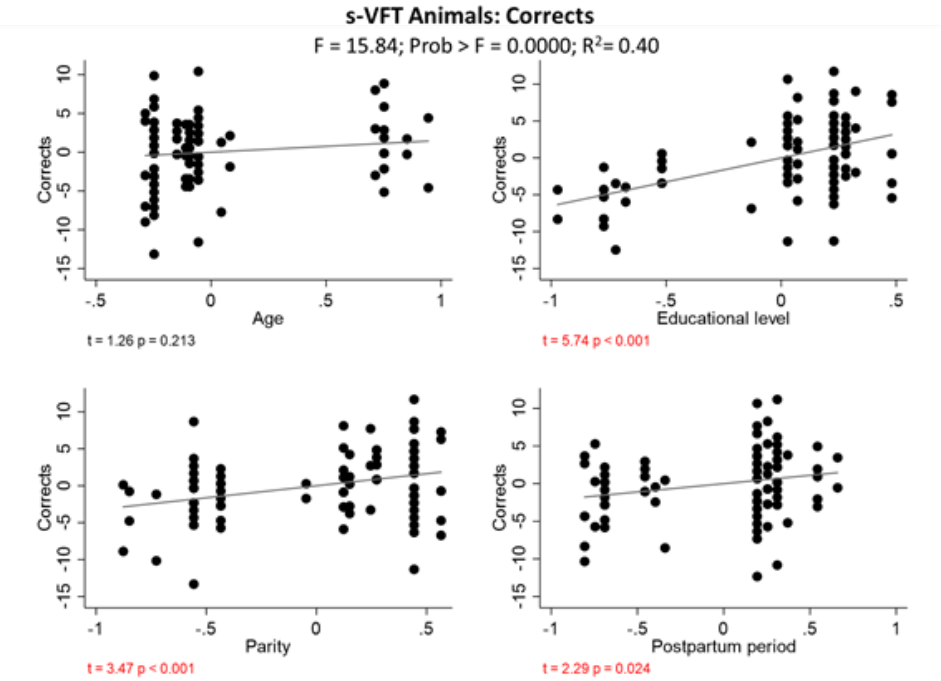

p-VFT Letter P: Isolated words
F = 1.46; Prob > F = 0.2281; R²= 0.10
Isolated words
Age
t = 0.21 p = 0.835
Educational level
t = 0.98 p = 0.331
Parity
t = 2.06 p = 0.045
Postpartum period
t = 0.64 p = 0.527

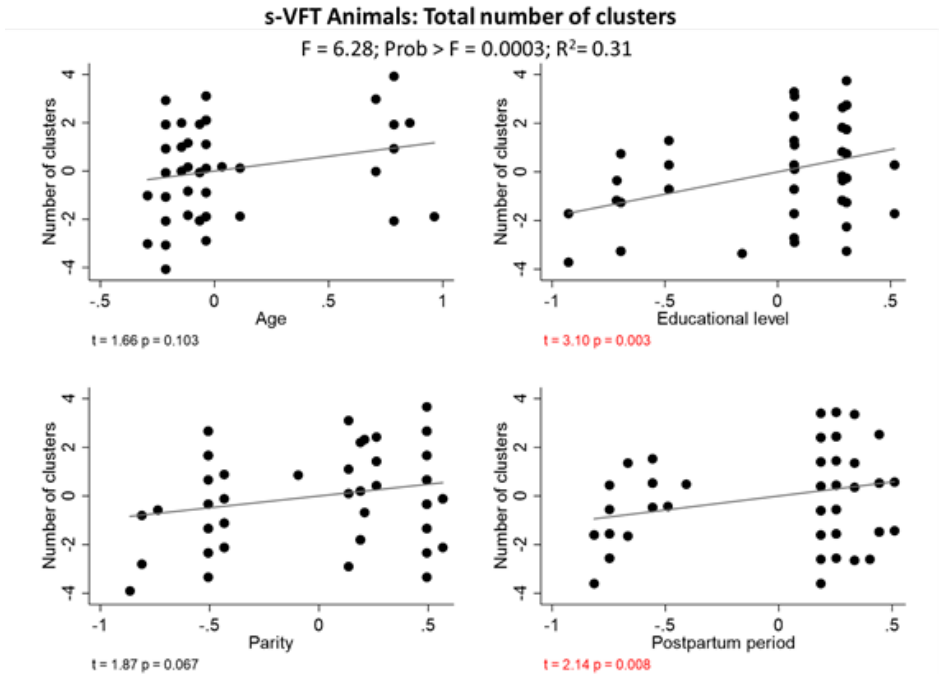

p-VFT Letter P: Switches
F = 2.40; Prob > F = 0.0609; R²= 0.15
Switches
Age
t = -0.53 p = 0.597
Educational level
t = 2.15 p = 0.036
Parity
t = 2.48 p = 0.016
Postpartum period
t = 0.46 p = 0.650

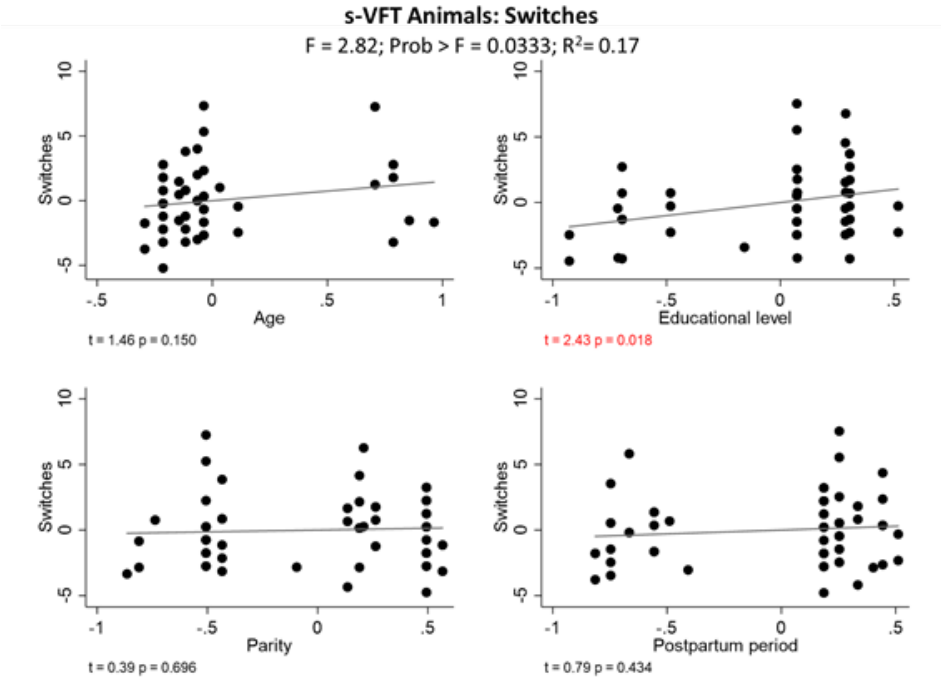

p-VFT Letter P: Returns
F = 1.56; Prob > F = 0.1969; R²= 0.10
Returns
Age
t = -0.75 p = 0.454
Educational level
t = 2.39 p = 0.020
Parity
t = 0.91 p = 0.368
Postpartum period
t = 0.02 p = 0.986

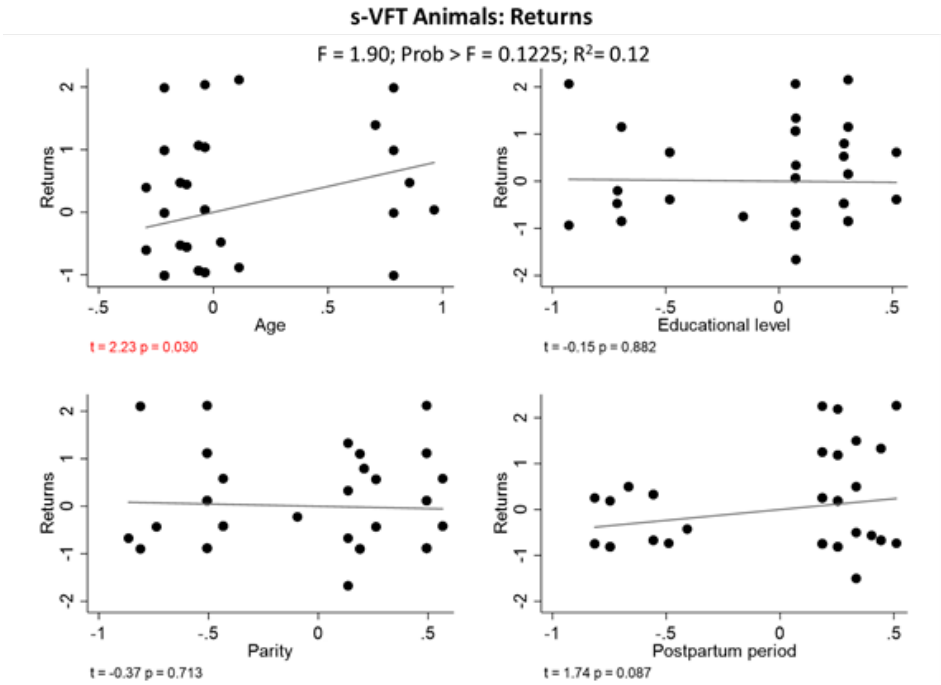

p-VFT Letter F: Corrects
F = 3.85; Prob > F = 0.0061; R²= 0.14
Corrects
Age
t = -0.86 p = 0.394
Educational level
t = 2.90 p = 0.005
Parity
t = 1.97 p = 0.052
Postpartum period
t = 1.26 p = 0.210

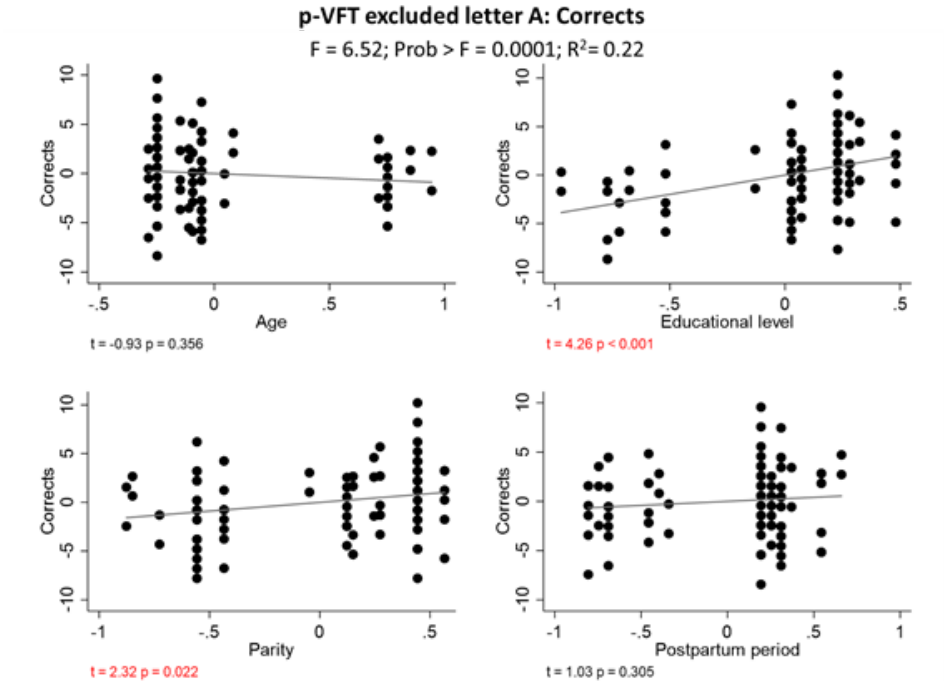

p-VFT Letter F: Errors
F = 3.48; Prob > F = 0.0107; R²= 0.13
Errors
Age
t = -0.43 p = 0.669
Educational level
t = 2.00 p = 0.048
Parity
t = 2.17 p = 0.033
Postpartum period
t = 1.81 p = 0.074

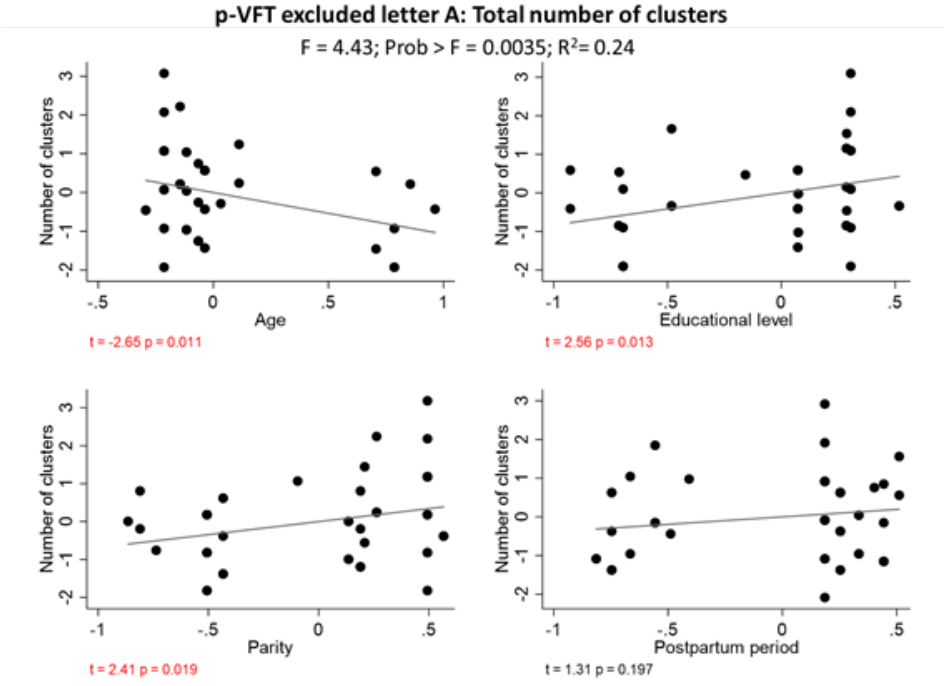

s-VFT Animals: Corrects
F = 15.84; Prob > F = 0.0000; R²= 0.40
Corrects
Age
t = 1.26 p = 0.213
Educational level
t = 5.74 p < 0.001
Parity
t = 3.47 p < 0.001
Postpartum period
t = 2.29 p = 0.024

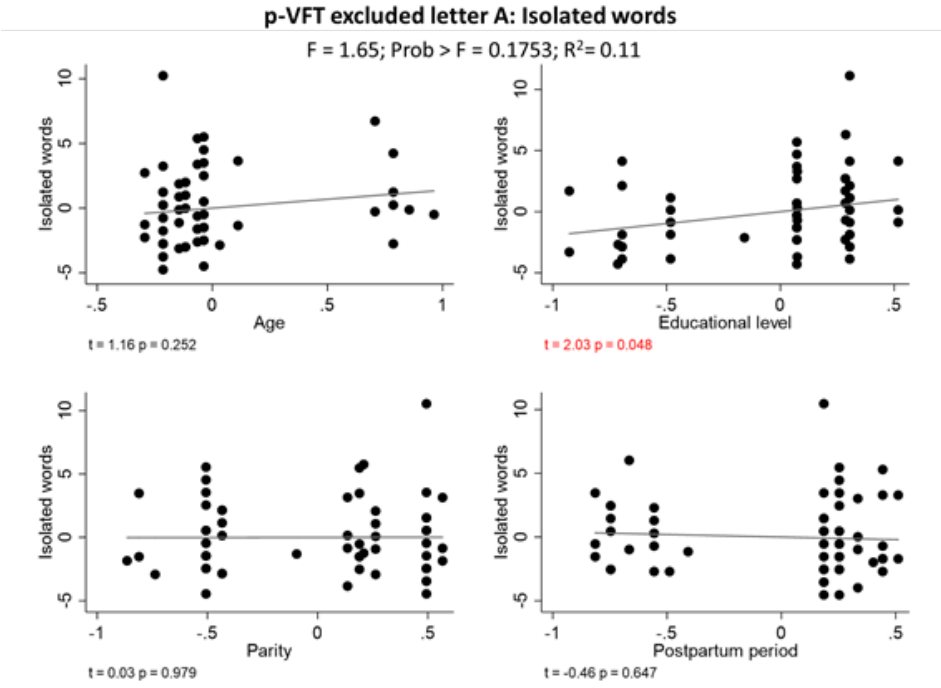

s-VFT Animals: Total number of clusters
F = 6.28; Prob > F = 0.0003; R²= 0.31
Number of clusters
Age
t = 1.66 p = 0.103
Educational level
t = 3.10 p = 0.003
Parity
t = 1.87 p = 0.067
Postpartum period
t = 2.14 p = 0.008

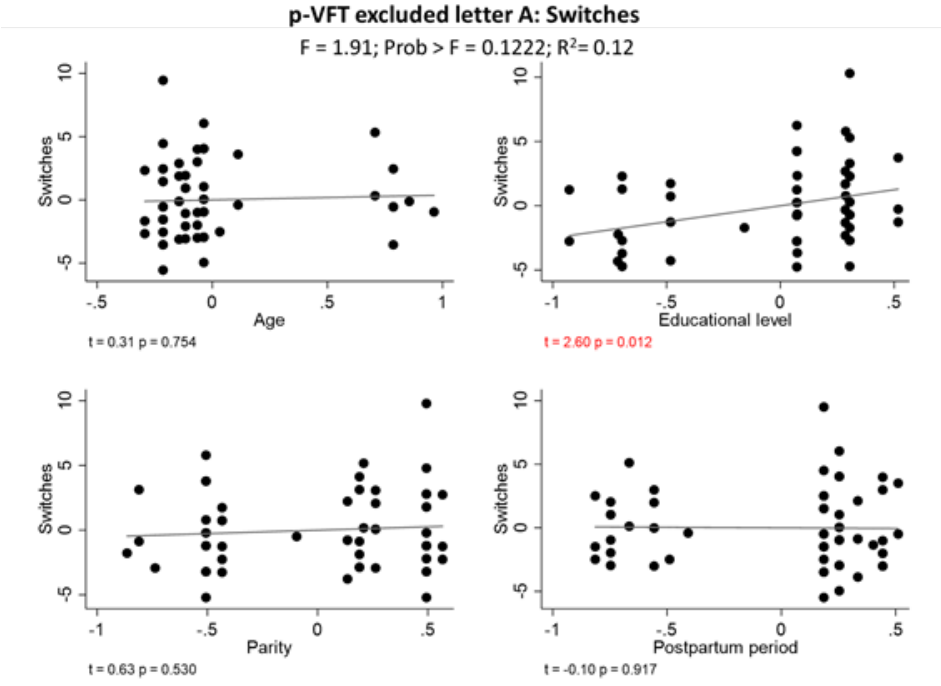

s-VFT Animals: Switches
F = 2.82; Prob > F = 0.0333; R²= 0.17
Switches
Age
t = 1.46 p = 0.150
Educational level
t = 2.43 p = 0.018
Parity
t = 0.39 p = 0.696
Postpartum period
t = 0.79 p = 0.434


s-VFT Animals: Returns
F = 1.90; Prob > F = 0.1225; R²= 0.12
Returns
Age
t = 2.23 p = 0.030
Educational level
t = -0.15 p = 0.882
Parity
t = -0.37 p = 0.713
Postpartum period
t = 1.74 p = 0.087


p-VFT excluded letter A: Corrects
F = 6.52; Prob > F = 0.0001; R²= 0.22
Corrects
Age
t = -0.93 p = 0.356
Educational level
t = 4.26 p < 0.001
Parity
t = 2.32 p = 0.022
Postpartum period
t = 1.03 p = 0.305


p-VFT excluded letter A: Total number of clusters
F = 4.43; Prob > F = 0.0035; R²= 0.24
Number of clusters
Age
t = -2.65 p = 0.011
Educational level
t = 2.56 p = 0.013
Parity
t = 2.41 p = 0.019
Postpartum period
t = 1.31 p = 0.197


p-VFT excluded letter A: Isolated words
F = 1.65; Prob > F = 0.1753; R²= 0.11
Isolated words
Age
t = 1.16 p = 0.252
Educational level
t = 2.03 p = 0.048
Parity
t = 0.03 p = 0.979
Postpartum period
t = -0.46 p = 0.647


p-VFT excluded letter A: Switches
F = 1.91; Prob > F = 0.1222; R²= 0.12
Switches
Age
t = 0.31 p = 0.754
Educational level
t = 2.60 p = 0.012
Parity
t = 0.63 p = 0.530
Postpartum period
t = -0.10 p = 0.917