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Executive Processing in Children on Verbal Fluency Tasks: The Predictive Role of Child Age and Parental Education

Geise Machado Jacobsen
Pontifical Catholic University of Rio Grande do Sul

Yves Joanette
Institut Universitaire de Gériatrie de Montréal

Christian Haag Kristensen and Rochele Paz Fonseca
Pontifical Catholic University of Rio Grande do Sul

Recent studies have found associations between parental education and child cognitive abilities. The influence of child age and parental education on executive development is still not well understood, especially on the cognitive processes underlying performance on unconstrained, phonemic and semantic verbal fluency tasks (VFT). The goal of the present study was to investigate whether child age and parental education predict child executive functioning on VFT. Unconstrained (UVF), phonemic–orthographic (PVF), and semantic (SVF) VFT were administered to 144 healthy participants, aged between 6 and 12 years. Results were analyzed using Pearson correlation coefficients and multiple linear regressions. The model that best accounted for the variance in verbal fluency scores included child age and paternal education (UVF: $R^2 = 0.51$, $p \leq .01$; SVF: $R^2 = 0.45$, $p \leq .01$). The influence of child age and parental education on verbal fluency performance may be explained by the increased cognitive stimulation received at home and at school by children who attended school for longer periods and whose parents had higher levels of education.

Keywords: age, executive functions, parental education, verbal fluency

A number of individual and sociocultural factors may influence childhood cognitive development. These factors include parental education (Aarnoudse-Moens, Weisglas-Kuperus, Duivenvoorden, Oosterlan, & Goudoever, 2012; Ardila, Rosselli, Matute, & Guajardo, 2005; Villaseñor, Martín, Díaz, Rosselli, & Ardila, 2009), socioeconomic status (Alloway, Alloway, & Wootan, 2014; Calvo, & Bialystok, 2014; Hackman, Gallop, Evans, & Farah, 2015), as well as the child's age (Arán-Filippetti, 2011a; García, Rodríguez, Martín, Jiménez, & Hernández, 2012; Nieto, Galtier, Barroso, & Espinosa, 2008), sex (Villaseñor et al., 2009), and the type of school they attend (Ardila et al., 2005; Villaseñor et al., 2009). However, there is a paucity of studies of the combined effects of these variables, especially on verbal fluency tasks (VFT).

Parental education, occupation, place of residence and family income are the main indicators of socioeconomic status. Recent years have seen a growing interest in studies of the influence of this variable on cognitive performance. Socioeconomic status (SES) is defined as the social and economic conditions experienced by a family over the course of their lives. Parental education, occupation and income have been associated with intelligence and cognitive abilities, suggesting that socioeconomic variables influence cognitive development and the functionality of neural networks (Alloway et al., 2014; Ardila et al., 2005; Calvo, & Bialystok, 2014; Castillo et al., 2011; Hackman et al., 2015).

Parental education levels are also related to IQ. Although variations in IQ are generally attributed to genetic factors, environmental fac-

Geise Machado Jacobsen, Psychology Department, Pontifical Catholic University of Rio Grande do Sul; Yves Joanette, Centre de Recherche, Institut Universitaire de Gériatrie de Montréal; Christian Haag Kristensen and Rochele Paz Fonseca, Psychology Department, Pontifical Catholic University of Rio Grande do Sul.

Correspondence concerning this article should be addressed to Geise Machado Jacobsen, Pontifical Catholic University of Rio Grande do Sul, Psychology Department, Postgraduate Program in Psychology, Avenue Ipiranga, 6681, Building 11, Room 932, 90619-900, Brazil. E-mail: geisejacobsen@gmail.com

tors may modulate gene expression, so that individual differences in intelligence can be seen as the result of a complex interaction between genetics and the environment. In summary, parental education levels may be related to both socioeconomic and genetic factors. The variability in cognitive abilities in the general population suggests that they are influenced by a number of different factors. However, there is a need for studies that investigate the role of different demographic factors in the development of specific cognitive abilities (Klenberg, Korkman, & Lahti-Nuuttila, 2001; Lemos, Almeida, & Colom, 2011; Rowe, Jacobson, & Van den Oord, 1999).

To better understand this relationship, some authors have investigated the association between parental education and child IQ. In a study of adolescents (Lemos et al., 2011) using the Reasoning Tests Battery as a measure of intelligence, the authors found a positive linear relationship between intelligence and parental education. Other authors (Rowe et al., 1999) have also analyzed the relationship between parental education and the heritability of IQ using verbal IQ tests, and found that parental education levels moderate the influence of genetic and shared environmental factors. IQ heritability increased from 25% in children of parents with less than 12 years of education to 75% in children whose parents had more than 12 years of formal study. Conversely, shared environmental influences decreased from 20%–40% in the lower education group to approximately zero in families where parents had higher levels of education. Therefore, improved environmental conditions may increase the heritability of genetic traits.

Researchers have also studied the association between parental education and child performance on specific cognitive tests. A study by Castillo et al. (2011) assessed verbal, mathematical and reasoning abilities in adolescents, and found a positive association between parental education and occupation and child cognitive performance. Parental education, especially the father's education level, was associated with better performance on the tasks used. In agreement with these findings, a study by Villaseñor et al. (2009) found a positive correlation between parental education and child performance on auditory and visual attention tasks, as well as on tests assessing verbal and visual memory.

The studies cited suggested that neuropsychological performance may be influenced by cultural and educational features. However, the influence of socioeconomic variables on the development of executive functions (EF) still remains largely unexplored, especially in Brazilian samples. Studies of this association could identify variables which contribute to differences in the EF of children of different ages, allowing clinical practitioners and teachers to better comprehend the childhood development process and to identify sensitive periods for cognitive stimulation. Studies of the association between EF and sociocultural variables could also contribute to the differential diagnosis of clinical conditions and cognitive/learning impairments resulting from poor cognitive stimulation.

There are a number of other reasons why the association between socioeconomic variables and EF should be further investigated. The frontal cortex, which is closely related to EF, may be influenced by a number of factors throughout its long postnatal developmental trajectory. Furthermore, studies have shown associations between a number of socioeconomic variables and frontal lobe activity (Arán-Filippetti, 2011a; Ardila et al., 2005; Catale, Willems, Lejeune, & Meulemans, 2012).

EF is an umbrella term referring to a number of cognitive and behavioral processes involved in developing adaptive strategies to achieve various goals. These abilities act in unison, allowing individuals to direct behavior toward specific goals, select adequate responses, plan, execute, regulate and assess behaviors and their consequences. Therefore, EF contribute to choosing efficient problem solving strategies, and are important for social development, emotion control and decision making (Anderson, & Reidy, 2012; Chan, Shum, Toulopoulou, & Chen, 2008; Diamond, 2013). The development of EF begins in childhood, and accelerates between the ages of 6 and 8 years. Development continues into adolescence and early adulthood, following the course of frontal lobe maturation (Anderson, & Reidy, 2012; Sun, Mohay, & O'Callaghan, 2009).

VFT are among the most commonly used in the assessment of executive functions, as they tap into inhibitory control, initiation and processing speed, as well as lexical-semantic and mnemonic processing (Lezak, Howieson, Bigler, & Tranel, 2012). The most common verbal fluency (VF) test use phonemic–orthographic

(PVF) and semantic (SVF) criteria (Arán-Filippetti, 2011b; Nieto et al., 2008). However, an unconstrained VF task (UVF), without any specific criteria for word retrieval, has also been developed by Le Blanc and Joanette (1996).

Given the wide applicability and sensitivity of VFT, they have been frequently used in studies of the association between parental education and EF. A study by Ardila et al. (2005) found significant positive correlations between parental education levels and VFT using different retrieval criteria, including graphic fluency, PVF and SVF. Klenberg et al. (2001) also found an effect of parental education on PVF and SVF scores, with children of parents with higher educational levels performing better on these tasks. Lastly, a study by Arán-Filippetti (2011a) found a positive correlation between children's PVF scores and maternal education level, with the latter variable explaining the highest amount of the variance in PVF scores.

As well as identifying the influence of parental education levels on VF performance, studies have also found that scores on these tests are influenced by the child's age (García et al., 2012; Nieto et al., 2008). However, these studies only use traditional VFT (PVF and SVF), and do not investigate the role of child education. Therefore, the influence of sociocultural and biological factors on UVF performance does not appear to have been studied.

To our knowledge, no studies have investigated the combined influence of child age and parental education on measures of EF. Therefore, the goal of the present study was to contribute to an unexplored area of research by investigating whether child age and parental education can predict children's executive processing on traditional VFT, as well as on the sparsely studied UVF task. More specifically, this study aimed to identify the independent and combined effects of child age and parental education on VF performance, and to assess the differences between the impact of maternal and paternal education on executive functioning.

Method

Procedure

This study is part of a larger project, "Child Neuropsychological Assessment: Sociodemographic, Psychometric and Neuropsychological Studies," approved by the Ethics Committee of the Pontifical Catholic University of Rio Grande do Sul (Protocol Number 09/04864). Data were collected in public schools in Southern Brazil during school hours, from children who agreed to participate in the study and whose parents had previously provided written consent. Assessment was conducted in a well-ventilated, well-lit and quiet room, in a session lasting approximately 30 min.

Participants

A total of 144 public school students (52% were female) from the city of Porto Alegre took part in the study. Participants were aged between six and 12 years ($M = 9$, $SD = 2.08$). The total sample was equally divided by age ($\chi^2 = 0.86$, $p = .99$) and sex ($\chi^2 = 0.25$, $p = .62$).

The following exclusion criteria were applied: (a) grade repetition, (b) complaints of learning difficulties, (c) oral language alterations, (d) uncorrected sensory deficits, (e) current or prior neurological or psychiatric illnesses, (f) scores at or below the 25th percentile (below mean score) on Raven's Colored Progressive Matrices (indicative of intellectual disability; Angelini, Alves, Custódio, Duarte, & Duarte, 1999), and (g) scores at or below cut-off on the Conners' Abbreviated Questionnaire (indicative of significant symptoms of disattention, hyperactivity and impulsivity; Barbosa & Gouveia, 1993). From the initial sample of 171 children, 27 were excluded (hearing impairment, $n = 3$; intellectual disability, $n = 11$; scores above the cut-off on Conners Abbreviated Questionnaire, $n = 8$; and neurological or psychiatric disorders, $n = 5$).

Instruments

The sociodemographic and health questionnaire was answered by parents or guardians. Investigates the child's demographic characteristics, as well as medical and school history. It also assesses SES by investigating living conditions and parental education level. The latter variable was assessed by inquiring about the number of years of education completed by the participant's mother and father. In Brazil, the first 8 years of schooling correspond to primary school; Years 9 through 11 are equiv-

alent to high school; and Years 12 to 16 years correspond to higher education.

Conners' Abbreviated Questionnaire (Barbosa & Gouveia, 1993) was used, and contains 10 statements referring to symptoms of disattention, hyperactivity and impulsivity. The questionnaire is answered by one of the participant's teachers, who rates each symptom item on the following scale: not present, a little present, pretty much present, or very much present.

In Raven's Colored Progressive Matrices (Angelini et al., 1999), he child is presented with a series of 36 pictures, each of which has a missing part. The respondent must then choose the piece that best completes each picture from the alternatives presented. The instrument aims to assess general cognitive ability (g factor).

The UVF, PVF, and SVF tasks adapted for children, from the Montreal Communication Evaluation Battery (Jacobsen et al., 2017), were used. In the UVF task, the child is asked to say as many words as possible during two and a half minutes, except for proper nouns. The other VFT last two minutes each. In the PVF task, the participant is asked to say as many words as possible starting with the letter 'p,' except for proper nouns. Last, in the SVF task, the participant is asked to recall as many words as possible in the semantic category "clothes." These tasks assess executive and lexical-semantic processing, attention and updating processes, the ability to create and initiate search strategies, lexical access, as well as cognitive flexibility, inhibition and working memory. SVF performance, specifically, requires semantic knowledge and memory, as it involves semantic associations. PVF, on the other hand, requires nonhabitual strategies to search for words beginning with the same letter (García et al., 2012; Hurks et al., 2010; Van der Elst, Hurks, Wassenberg, Meijs, & Jolles, 2011).

Data Analysis

The Pearson's Correlation Coefficient ($p \leq .05$) was used to search for correlations between parental education levels and child VF performance. Lastly, a Stepwise Multiple Linear Regression based on correlation analysis results was used to further explore the relationship between parental education and the VF performance of children. Predictor variables were entered into the model in the following order: child age, maternal education, and paternal education. The child age was the first variable, because this factor is widely studied and have been shown to have a significant impact on cognitive development (e.g., Brocki, & Bohlin, 2004). Then, maternal education was added to the model. Compared with paternal education, this variable has been more emphasized in studies of the role of sociocultural factors in cognitive development, so it was inserted before (e.g., Arán-Filippetti, 2011a). Dependent variables were raw scores on the UVF, PVF, and SVF tasks (total number of correct words).

Results

Table 1 presents the means and standard deviations of the number of years of maternal and paternal education, as well as of children's scores on UVF, PVF, and SVF tasks. Child age showed moderate correlations with the three VFT ($r = .55$ to $r = .66$). Maternal education had weak to moderate associations with the VFT ($r = .15$ to $r = .27$). Paternal education presented moderate correlations with UVF ($r = .29$) and SVF ($r = .30$). Table 2 displays the stepwise multiple linear regression results, which investigated the relationships between the child's age and education, parental education levels and children's scores on UVF, PVF, and SVF tasks.

Discussion

The present study sought to investigate whether child age and parental education can predict executive performance assessed by UVF, SVF, and PVF tasks. Positive correlations

Table 1
Means and Standard Deviations of Maternal Education, Paternal Education, and Total Score on UVF, PVF, and SVF

Variables	*N*	*M*	*SD*
Maternal education	144	11.42	3.80
Paternal education	144	11.18	3.42
UVF	144	37.95	19.62
PVF	144	12.65	6.09
SVF	144	14.27	5.77

Note. UVF = unconstrained verbal fluency; PVF = phonemic verbal fluency; SVF = semantic verbal fluency.

Table 2
Stepwise Multiple Linear Regressions of UVF, PVF, and SVF Scores on Child and Paternal Education Level

Model	Independent variable	Dependent variable	R	R^2	ΔR^2	β
1	Child age	UVF	.67	.46	.46	.67**
2	Child age		.72	.51	.063	.66**
	Paternal education					.25**
1	Child age	PVF	.56	.31	.31	.56**
1	Child age		.62	.38	.38	.62**
2	Child age	SVF	.68	.45	.07	.61**
	Paternal education					.27**

Note. UVF = unconstrained verbal fluency; PVF = phonemic verbal fluency; SVF = semantic verbal fluency.
** $p \leq .01$.

ranging from weak to moderate were identified between each parent's education level and total scores on UVF and SVF. Child age was moderately correlated with performance on all VF tasks. Therefore, children of parents with higher education obtain higher scores on VF tasks. The present study also found that child age and paternal education levels explain 50% of the variance in UVF scores and 45% of the variance in SVF scores. In the PVF, only the child age predicted performance, and accounted for 30% of the variance in scores.

Results of correlation and regression analyses of SVF scores were in agreement with findings by Brocki and Bohlin (2004); García et al. (2012) and Pureza, Gonçalves, Branco, Grassi-Oliveira, and Fonseca (2013), wich found age differences in child performance on measures of verbal fluency. The results are also in agreement with the studies of Ardila et al. (2005); Arán-Filippetti (2011a) and Klenberg et al. (2001), which found that parental education levels influenced child performance on the task. However, analyses of PVF scores suggested that only the child age predicted performance, which was not in agreement with the previously cited studies. It is possible that PVF is more directly related to the child education, which progresses with age, as this task requires phonological awareness and knowledge of formal aspects of language. UVF and SVF make larger demands on lexical-semantic resources, and are more closely associated with parental education, as this variable influences the parents', and consequently the child's, vocabulary knowledge (Hurks et al., 2010). The association between the child age and performance on the three VF tasks can be explained by the child's phonological awareness, vocabulary knowledge and formal knowledge of language, which develop throughout the education process, in addition to the brain maturation process.

It should also be noted that the literature suggests that SVF is more sensitive than PVF for assessing executive processes (Arán-Filippetti, 2011b). Therefore, SVF is more likely to be able to detect the effect of parental education on EF. This hypothesis was confirmed by the present findings. The PVF task used in the present study, which was two minutes long and used the letter P as a phonemic criterion, was also distinct from the tasks used in the other studies mentioned, which are one minute long and use letters A, F, K, M, and S. These differences may also have influenced results. The higher correlations between independent variables and scores on the UVF task suggest that it may provide a more sensitive assessment of EF. Therefore, this instrument would be a valuable addition to EF assessment batteries.

The present findings may be explained by the fact that parents with higher education levels, especially those with undergraduate degrees, have different attitudes and cultural values than parents with lower levels of education. These characteristics may lead to differences in the childhood environment provided by the parents, in the nature of parent–child activities and in the values passed down to the children (Ardila et al., 2005). Therefore, it is possible that parents with higher levels of education provide

more cognitive stimulation to their children, contributing to the development of EF and leading to better performance on tests that assess these abilities (Aarnoudse-Moens et al., 2012; Arán-Filippetti, 2011a; Ardila et al., 2005; Calvo, & Bialystok, 2014; Castillo et al., 2011; Lemos et al., 2011; Rowe et al., 1999; Villaseñor et al., 2009). Some of the SES-related factors which have been found to influence the level of cognitive stimulation in the home include the availability of computers, travel opportunities and parental communication (Hackman, Farah, & Meaney, 2010).

Furthermore, studies suggest that parents with higher levels of education have higher lexical variety, read more to their children, use longer sentences and a richer vocabulary. These features may accelerate language development, and encourage children to use a richer lexicon, and develop better language and cognitive skills in general, contributing to scores on VF tasks (Aarnoudse-Moens et al., 2012; Arán-Filippetti, 2011a; Calvo, & Bialystok, 2014; Catale et al., 2012; Villaseñor et al., 2009).

Investigations of linguistic processes are also important to elucidate the role of language in the development of other cognitive processes. Although language is considered a cognitive mediator (Villaseñor et al., 2009), and is able to influence performance on some EF tasks, the nature of this influence is still unclear (Catale et al., 2012).

Studies also show that parental education may influence affect, parenting style and the way in which parents interact with their children (Ardila et al., 2005; Davis-Kean, 2005). For instance, some studies suggest that cognitively rich interactions between mother and child are an important predictor of self-regulation and impulse control (Arán-Filippetti, 2011a). This could, in turn, influence performance on VF tasks, which involves inhibitory control and the choice of effective word retrieval strategies. Instructional materials used by parents to teach children to read, the learning opportunities provided and the social support offered to children also differ as a function of parental education. Relationships between children's reading habits and parental education levels have also been identified (Arán-Filippetti, 2011a; Ardila et al., 2005; Castillo et al., 2011; Davis-Kean, 2005; Hackman et al., 2010).

Therefore, it is possible that parental education itself, as well as all other related factors, from cultural values to parental reading habits, contribute to a cognitively stimulating environment for children. These findings suggest that the effect of parents' education on the environment they provide to their children may influence brain maturation and, consequently, executive development (Arán-Filippetti, 2011a; Hackman et al., 2015).

In summary, the maturation of underlying brain structures, which is intrinsically connected to the development of EF, is influenced by parental education. The vulnerability of these developmental processes to environmental factors may be explained by their duration, extending from childhood to young adulthood (Arán-Filippetti, 2011a; Catale et al., 2012).

The results of the regression analysis suggested that the model that explained the most variance in VF scores included child and the paternal education levels. This model accounted for 50% and 45% of UVF and SVF scores, respectively. The independent variables appeared to influence EF in a cumulative fashion, where child and paternal education influenced VF performance both independently and in tandem.

The present results suggested that no factor was solely responsible for the variance in EF scores, but that VF performance was influenced by a combination of independent variables. Although parental education is one of the most significant environmental influences on cognitive development, other variables may also impact the ontogenetic evolution of cognitive abilities. Age, education and the type of school attended by children, as well as socioeconomic factors such as parental occupation, SES and family income may also influence cognitive development (Arán-Filippetti, 2011a; Ardila et al., 2005; Castillo et al., 2011; García et al., 2012; Klenberg et al., 2001; Nieto et al., 2008; Villaseñor et al., 2009).

The present results are relevant to clinical and educational settings, as they underscore the importance of early intervention at critical periods of structural and functional prefrontal cortex development (Arán-Filippetti, 2011a). Therefore, the present findings contribute to the comprehension of the complex influence of parental and child education on executive processing, which could guide public policies and help de-

velop preventive interventions in health and education.

In light of these results, we conclude that interventions involving the stimulation of EF in schools could make especially useful contributions to the learning process. Psychoeducational interventions for parents and guardians could also play an important role in promoting awareness of the importance of motivating children to read and engage in cognitively stimulating activities. Shared, guided and independent reading from both print or electronic sources must be encouraged both at home and at school. Teachers can also be trained to develop activities that promote the stimulation of EF in children both at home and at school, and to instruct parents on how to assist their children with these tasks at home.

The present findings also show that the applicability of neuropsychological models of EF to the planning and implementation of cognitive stimulation programs must be further explored, especially since such initiatives may mitigate the negative effects of low SES on the cognitive development of children who come from culturally impoverished homes. Both educators and health professionals may be trained to develop such interventions and to provide orientations to parents on the stimulation of EF at home. The implementation of cognitive intervention and parental psychoeducation programs may be an important focus of public policy in health and education. In conclusion, although the present findings have made important contributions to the study of sociocultural variables and childhood cognitive development, further studies are needed to explore the effect of additional variables such as reading habits and SES on cognitive development, as well to better comprehend the role of other sociocultural variables which have only begun to be studied in the literature.

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