Psicologia: Teoria e Prática
ISSN: 1516-3687
ISSN: 1980-6906
revistapsico@mackenzie.br
Universidade Presbiteriana Mackenzie
Brasil

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Psicologia: Teoria e Prática, vol. 20, núm. 3, 2018
Universidade Presbiteriana Mackenzie, Brasil
Disponible en: https://www.redalyc.org/articulo.oa?id=193860127004

Avaliação psicológica

Executive functions in preschool children: development and relationships with language and behavior

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Abstract: This study investigated the development of executive functions (EF) and their relationship with oral language (OL), initial reading and writing (RW) skills and behavior in preschoolers. Participants were 32 children, aged between 3 and 6 years, from a private school in São Paulo (Brazil). They were evaluated with individual tests and a scale answered by parents and teachers. There was an increase in performance in EF according to the school level. Significant correlations were observed between at least one measure of each EF test and OL and RW tests, except pseudowords repetition measure. EF scales were correlated with OL and RW tests, especially when reported by teachers. Children with better EF also had less behavior problems. The results confirm the importance of evaluating EF in preschool children given their relationship with other areas of infant development.

Keywords: executive function, literacy, preschool, evaluation, functionality.

Psicologia: Teoria e Prática, vol. 20, núm. 3, 2018

Universidade Presbiteriana Mackenzie, Brasil

Recepción: 28 Junio 2017
Aprobación: 11 Junio 2018

Redalyc: https://www.redalyc.org/articulo.oa?id=193860127004

Introduction

Several studies suggest the importance of preschool age development, as well as the possibility of early identification of future learning difficulties, which contributes to the development of intervention programs (e.g., Baptista, Osório, Martins, Verissimo, & Martins, 2016). This interest and growth of the area are in line with international trends that have consistently reinforced the importance of the development and stimulation in this period for success throughout life in different areas (Center on the Developing Child - CDC, 2011).Recently, studies have emphasized the importance of Executive Functions (EF) for learning, behavior, and social adjustment (Diamond, 2013; Schoemaker, Mulder, Dekovic, & Matthys, 2013), as well as several outcomes throughout life (Moffitt et al., 2011). The literature also highlights the relevant role of early interventions in stimulating EF, e.g., in the preschool curriculum, and their potential to minimize difficulties and promote academic and social success. EF are cognitive skills needed to plan, initiate, implement, and monitor goal-oriented behaviors that allow the individual to act adaptively in the world (Diamond, 2013). This includes skills such as inhibitory control (IC; inhibition of attention and/or impulsive behavior); working memory (WM; mentally operate information to solve problems); and cognitive flexibility (CF; consider different perspectives; Diamond, 2013). EF develop more intensely in childhood, in parallel with children's cognitive and emotional maturation, so that they will

become capable of managing their thoughts, emotions, and actions. There is an important development of these skills between 3 and 5 years of age, with a long course that continues throughout childhood and adolescence (CDC, 2011).Although EF have been identified as an important predictor for learning and behavior outcomes (e.g., Dias, Prust, & Seabra, submitted; Nelson et al., 2018; Schoemaker et al., 2013), some studies also have highlighted the role of other abilities in its development. It is the case of oral language (OL; Bishop, Nation, & Patterson, 2014; Gordon-Pershey, 2014; Roello, Ferretti, Colonnello, & Levi, 2015). For example, Gordon-Pershey (2014) argues that we use language to think and reason. In this sense, we can make sense of thoughts and strategies putting it into words, which in turn helps us to govern behavior. The author highlights the development of language as a tool that enables the use of an inner language (a kind of self-talk) to guide actions. Indeed, one strategy to improve EF is the use of language, since it helps bring EF into conscious focus.The relationship between EF and OL was also considered by Bishop et al. (2014) in a perspective of impairment. The authors propose some models to explain the association between EF and language deficits: (a) EF impacts language; (b) language impacts EF; and (c) a third factor is underlying both, language and EF. We also can consider that models (a) and (b) could be combined, considering reciprocal influences in language and EF development (for example, while good EF skills could facilitate language learning, also the use of language/verbal mediation could foster EF).Considering a developmental perspective, Roello et al. (2015) argue that language acquisition and EF development are interdependent. These authors assessed children with specific language impairment (SLI) and controls in two age groups: young (53.6 months) and old (65.4 months). They found that EF impairment was already evident in the young group, in the preschool period, and concluded for possible difficulties in using language as a tool for reasoning and guiding behavior in SLI.Both EF and language skills can be considered foundations for learning. Specifically, EF are predictive of success on formal learning (Dias et al., submitted; Lawson & Farah, 2015). For example, Dias et al. (submitted) found that EF in preschool age can predict academic achievement in reading and math in a two-year longitudinal design. For the authors, EF are processes underlying learning, allowing children to focus attention and choose behavior, and, at the same time, can mediate learning-related behaviors, such as keeping in task despite some more interesting to do, asking for help or clarification and others that can impact their capacity to benefit from the instruction. Also, even in preschoolers, EF are related to initial RW skills (Shaul & Schwartz, 2014). These skills, in turn, include knowledge of letter and sound, writing of one's own name, and simple words reading and writing and, along with OL, can be considered as school readiness skills once they are predictors of future performance in the 1st grade of elementary education (Pazeto, 2016).As evidence in this area, a study found consistent relationships between EF and school readiness skills (as emergent literacy, phonological awareness, and also

emergent mathematical knowledge) in children of 5 and 6 years old. Besides this, EF arose with a significant contribution to emergent literacy and mathematical knowledge. In this regard, the authors mentioned that results corroborate the view of EF as a fundamental and general base for the development of pre-academic skills. But, it is interesting to note that the authors found the strongest contribution of EF for orthographic knowledge, even after controlling for language skills. It can be due to the fact that emergent orthographic knowledge is a very complex ability, which demands a number of skills such as grapheme-phoneme correspondence, visual perception print knowledge, word pattern recognition, and others so that EF would have an important role in this acquisition (Shaul & Schwartz, 2014).In addition, EF development has been linked to behavioral issues and childhood mental health. A recent meta-analysis (Schoemaker et al., 2013) shows a consistent relationship between EF, more specifically inhibition, and externalizing behavior problems in preschoolers. Regarding internalizing behavior problems, Nelson et al. (2018) found that EF in preschool age can predict symptoms of depression and anxiety when children reach the 4th grade. With a national sample, Dias, Trevisan, León, Prust, & Seabra (2017) found evidence of EF, mainly IC and CF, as predictors of ratings as emotional symptoms (IC and CF), behavior problems (only IC), hyperactivity (IC and also WM), peer relationship problems (CF), and prosocial behavior (CF) in preschoolers. Behavior and social adjustment measures seem to mediate the effect of EF on school readiness from as early as three years of age (Baptista et al., 2016).Even though there have been many previous studies, few have contemplated all these skills in a single investigation, to delineate their relationships at early ages. So, this study investigated the development of EF and their relationship with OL, initial RW skills and behavior in children aged 3 to 6 years. Regardless of a low age range, we expect to identify some developmental trends, with older children showing better performance in the EF performance tests. Also, even in this early age range and without considering for causal relationships, we expect to find correlations, most moderate, between EF (assessed by performance tests and a functional scale) and all other measures, evidencing the associations of these abilities with OL, initial RW skills, and behavior.

Method

Study Design

This was an observational and correlational study.

Participants

Initially, 37 children, aged between 3 and 6 years, from the nursery, Pre1 and Pre2 of an early childhood education private school of São Paulo (Brazil) participated in the study. Three children left school during data collection, and two children were excluded from the final sample due to diagnosis or presence of neurodevelopmental disorders signs, according to information obtained by the school administration. So, the final sample

consisted of 32 children with a mean age of 4.5 years (50% girls), with 15 of the children from the nursery (mean age = 3.47, SD = 0.52), 8 from Pre1 (mean age = 4.22, SD = 0.44) and 9 children from Pre2 (mean age = 5.4, SD = 0.52) of an early childhood education private school of São Paulo (Brazil).

Instruments

Evaluation of the EF

- Trail Making Test for Preschoolers (TMTP; Seabra & Dias, 2012a): evaluates CF. In Part A, there is a five dogs' family image where the child must connect them by ascending size. In Part B, the child must alternate the stimuli (dogs and bones) by ascending size.- Semantic Stroop Test computerized (SST; Trevisan, 2010): evaluates selective attention and IC. There are two pairs of figures: sun and moon, boy and girl. In Part 1, the child must name them individually. In Part 2, she must inhibit the automatic response and name the opposite figure.- Cancellation Attention Test (CAT; Seabra & Dias, 2012a): evaluates attention through 3 matrixes with diverse stimuli, with a target stimulus needing to be canceled within the time of 1 minute for each part. Parts 1 and 2 assess selectivity, and Part 3 includes alternation demands.- EF Difficulties Inventory, Regulation, and Aversion to Postponement - Version for children and adolescents (EFDI; Trevisan, 2010): assesses EF in day-to-day situations through observation by parents and teachers. It consists of 28 items in a Likert scale of 1 to 5 ("never", "rarely", "sometimes", "often", "always"), divided into 5 subscales: WM (5 items), IC (6 items), CF (5 items), Delay Aversion - DA (5 items) and Regulation - RG (7 items). A higher score indicates greater difficulty.

Behavior evaluation scale

- Strengths and Difficulties Questionnaire (SDQ; Stivanin et al., 2008): assesses behavior (strengths and difficulties) in children and adolescents, through the responses of parents and teachers. It contains 25 items divided into 5 subscales: Emotional Symptoms (ES), Conduct Problems (CP), Hyperactivity Disorder (HD), Relationship Problems with Colleagues (RPC), and Pro-Social Behavior (PSB), in a Likert scale of three levels ("False", "More or less true" or "True"). A higher score indicates greater difficulty, except for PSB scale.

Evaluation of oral language

- Phonological Awareness by Oral Production Test (PAOPT; Seabra & Dias, 2012b): evaluates the ability to manipulate speech sounds mentally. It is composed of 10 subtests that assess awareness of syllables, rhymes, alliterations, and phonemes.- Peabody Picture Vocabulary Test (PPVT; Capovilla & Capovilla, 1997): evaluates the comprehension of auditory receptive vocabulary. It consists of 5 training items and 125 test items, and in each item the subject should select the figure that best represents the word heard from 4 figures presented.- Repetition of Words and Pseudowords Test (RWPT; Seabra & Dias, 2012b): evaluates the phonological short-term memory capacity. It consists of 16 items, 8 for the repetition of words and 8 for pseudowords, ranging from 2 to 5 items that are pronounced by the applicator for the child

to repeat.- Childhood Naming Test (CNT; Seabra & Dias, 2012b): evaluates expressive language and access to long-term memory through a picture naming task. It consists of 60 items, with pictures of objects, animals, and people.

Reading and writing assessment

- Letters and Sounds Recognition Test (LSRT; Pazeto, Leon, & Seabra, 2017): divided into 2 parts (letters and sounds). In both, 1 letter is presented per sheet, in a random order, and the subject should say the names and sounds of the letters, respectively.- Name Writing Task (NWT; Pazeto, 2016): assesses the ability of the child to write his/her first name, considering the sequence of correct letters, even if mirrored.- Reading and Writing Test (RWT; Pazeto et al., 2017): evaluates the ability to read and write 8 words and 2 pseudowords.

Procedure

After approval from the Research Ethics Committee (REC No. 13848213.1.0000.0084), the school was contacted and the consent form was sent to those responsible for the school and for the children. The EFDI and the SDQ were sent to the parents and teachers. Initially, the OL tests were applied to all the children; then due to the complexity of the other tests, the RW tests (only applied to Pre1 and Pre2), and finally the EF tests (only the SST was applied to all the grades). The children responded individually to the tests during school time, in a room reserved at the school, in six sessions of 5 to 20 minutes. The distribution of the applications occurred in the following sequence: 1. CNT and RWPT; 2. PPVT; 3. PAOPT; 4. LSRT, NWT, and RWT; 5. SST; and 6. CAT and TMTP. There was an interval of 7 days between one session and another.

Data analysis

The Statistical Package for the Social Sciences (SPSS) v.21.0 was used for the analysis. Given the small sample size and the fact that not all the measures obeyed the normality assumption (according to the Kolmogorov-Smirnov test), nonparametric analysis was conducted. The Mann-Whitney test was used to compare the performances in the CAT and TMTP tests between Pre1 and Pre2. The Kruskal-Wallis test was used to compare the performances of the nursery, Pre1, and Pre2 in the TSS measures. For all the comparisons, the effect size (Cohen's d) was calculated. Relationships of the EF measures, both the performance tests (CAT, TMTP, and SST, with measures selected with greater EF demand in each test) and the functional measure (EFDI), with the OL and written and behavioral measures were verified using Spearman's test. In all the cases, the level of significance of $p < .05$ was adopted.

Results

There was an increasing trend in the CAT and TMTP performances according to the school level for most the measures. The Mann-Whitney test revealed a significant difference, with better performance of Pre2 in the CAT Part 3 ($U = 21.50$; $p = .054$; $d = 1.02$) and its total ($U = 21.00$; $p = .050$; $d = .73$), with large and moderate effect sizes, respectively.

Despite the lack of statistical significance, Cohen's d values indicated a moderate effect size for the performance in the CAT Part 2 (U = 35.00; p = .387; d = .55) and a large size in the TMTP Part B (U = 25.50; p = .104; d = .90). For the SST, the descriptive statistics suggest improvement in performance, with higher scores in both parts of the test and reduction in the interference score (IS) of the nursery for the subsequent levels, both presenting relatively similar scores. This difference was significant, with a large effect size, in the SST Part 2 (X2 = 6.199; p = .045; d values in the comparisons of each pair: nursery and Pre1 = .78; nursery and Pre2 = .86; Pre1 and Pre2 = .08). The IS, despite not reaching statistical significance, presented a moderate effect size, with less interference of condition 2 of the SST in children of the levels Pre1 and Pre2 in relation to those of the nursery (X2 = 4.270; p = .118; d values in the comparisons of each pair: nursery and Pre1 = .82; nursery and Pre2 = .73; Pre1 and Pre2 = .10). The Reaction Time (RT) measures presented the most irregular pattern, with increased time for the children of the nursery compared to those of Pre1 and decreased compared to those of Pre2 in Part 1, and decreased time for the nursery compared to Pre1 and a further increase for Pre1 compared to Pre2 in Part 2, a pattern that was repeated in the interference RT. Statistical significance was observed in these last two measures, with a large effect size (RT Part 2 - X2 = 9.359; p = .009; d values in the comparisons of each pair: nursery and Pre1 = 1:15; nursery and Pre2 = 01.07; Pre1 and Pre2 = .24 / Interference RT - X2 = 7.264; p = .026 ; d values: nursery and Pre1 = .85; nursery and Pre2 = .60; Pre1 and Pre2 = .63). In RT Part 1, despite the effect not reaching statistical significance, the effect size was moderate (X2 = 3.875; p = 1.44; d values in the comparisons of each pair: nursery and Pre1 = .14; nursery and Pre2 = .71; Pre1 and Pre2 = .54). As would be expected, all the groups were faster in Part 1 than in Part 2.Several correlations between the EF measures and performances in OL and initial RW skills were found, especially when considering the EF performance tests (Table 1), apart from some correlations with functional measures (parents and teachers answers; (Table 2). Regarding the EF performance tests, the correlations tended to be moderate to high (with some very high; rho >.80). The attentional measures were related to almost all performances in OL, reading, and writing. The measure of CF was related to those of OL, knowledge of letters and writing (but not to that of reading), while the measures of inhibition were associated with those of OL, writing and, marginally, reading.Considering the responses of parents and teachers to EFDI (Table 4), the correlations were mostly moderate, however, varied from low to high. All were negative, as expected, since EFDI score provides an index of difficulty. Perhaps linked to the task difficulty, the measure of writing was the one that established more relations with EF indices, considering responses of both parents and teachers. However, it should be noted that more relations were established with EF measure answered by teachers compared to those answered by parents.Correlations between EF and behavioral indices are presented in Tables 3 and 4. Considering the EF performance

tests (Table 3), the relations established were all negative, as expected, since the SDQ indices that established relations with the tests measure behavioral difficulties. The relations tended to be moderate, with few low or high. Considering teachers' responses, HD subscale correlates more with performances of attention, CF, and IC tests. The total score in the SDQ was also related to performance in all EF tests.Considering parents' responses, negative relations were observed between measures of attention and ES and CP scales. Furthermore, HD subscale was associated, negatively, with measures of attention and CF test, and positively with the measure of RT in IC test. A similar pattern was observed in the total score of SDQ, with negative relations with attention measures and positive with RT measures in IC test.Correlations between EF and behavior were also found when considering the scales answered by parents and teachers (Table 4). Positive, low to high correlations were observed between total indices of the SDQ and virtually all EF measures, even when relations between different respondents were considered.As regards EF evaluated by teachers, correlations were established with behavior evaluated by both respondents, which were mostly moderate, however, varied from low to high. HD was the index that established more relations with all EF measures evaluated by teachers and most of the measures evaluated by parents. Some relations were negative. This was expected for PSB indices, where a higher score corresponds to better ability. The negative correlation between ES and IC was not expected and suggests that children evaluated with less difficulty in IC would have greater difficulty with ES. This point will be investigated in the discussion.Considering EF evaluated by parents, correlations were again established with behavior evaluated by both respondents, which were of low to high magnitude. There was a negative correlation between ES and RG index. Again, HD, assessed by both respondents, presented the most associations with EF indices. Overall, the results suggest that better EF indices, independent of the respondent, are associated with better indices of behavior.

Discussion

The study investigated the EF development and their relationship with OL, initial RW skills and behavior in preschool children, specifically aged between 3 and 6 years. The interest in this age group has grown in recent years and the variables investigated have already been the focus of numerous studies (e.g., Baptista et al., 2016; Dias et al., 2017; Schoemaker et al., 2013). This study, however, has integrated these variables in a single investigation to enable the relationships between the EF and the other variables to be explored in the early ages of development.Initially, there was an effect of school level on the performance in EF tests. These results corroborate the literature that, in general, discusses the EF development throughout childhood and highlights the preschool period as a time of rapid growth of these skills (CDC, 2011). However, more specifically, findings suggest that IC presents more pronounced development at an

earlier stage (here, for example, from the nursery to Pre1 and Pre2, which had no major differences between them) in relation to attention and CF abilities, measures that will be better differentiated successively at Pre1 and Pre2. This conclusion is supported by some evidence that suggests that IC would be one of the first EF to emerge, while CF, due to its greater complexity, would present more delayed development (Diamond, 2013).Regarding the relationship between EF and measures of OL and initial RW skills, considering both the performance of children in the tests and the functional measure significant correlations were identified. In all cases, correlations indicated that children with better EF skills also had better performance in the other measures. More robust associations were found when considering the EF performance tests. It is interesting to note that some variables established strong correlations with OL and initial RW skills, as was the case of CAT Part 3. This part of the test had alternation demands, besides selectivity, and its correlations with OL and RW variables varied from .49 to .90 (this last one with the writing measurement). In general, variables of all EF tests associate with OL and RW measures, showing some shared variance of attention, CF and IC with OL and initial RW in preschoolers.Considering the functional measures in general, it is difficult to derive a pattern in which certain EF skills are associated with certain language skills and school readiness for parent's ratings, WM and RG were associated with performance in some RW initial skills. For teachers' ratings, besides WM and RG also showed associated with performance in RW initial skills, CF and DA were correlated with some variables of RW initial skills and some of OL. All correlations were negative, evidencing that children better rated by parents or teachers had also better performance in the other measures, but the associations had low to moderate magnitude. It can be due to different kinds of measures (performance tests versus functional/ report scale), composing a multimethod approach.Some points can be highlighted. First, in general, teacher's ratings revealed a greater number of associations with OL and RW measures than parents'. We can raise some hypothesis about it, as the possibility that teachers could be in a better condition to rating children's abilities, due to their knowledge of development and behaviors expected for each age, what could allow for a more reliable measure of EF by such responders. Also, we should consider the different environments that could lead to different demands (home versus school), maybe facilitating the observation of some behaviors and skills. Also noteworthy is the fact that the most evident pattern along the correlations found was the association between EF, rated by teacher and parents, with writing measure. The writing measure can be the most difficult of our measures. It agrees with findings of others, which evidences point for a greater contribution of EF for orthographic knowledge in 5-6-year-old children, considering the complexity of this ability (Shaul & Schwartz, 2014). So, it is possible that children with better abilities of RG, WM, and CF can have some advantage in the acquisition of basic writing skills.The correlations between EF and OL skills were expected, as the literature has already discussed this relation (Bishop

et al., 2014) and even the role of OL in EF development (Gordon-Pershey, 2014; Roello et al., 2015). For example, for Gordon-Pershey (2014), language skills development allows for the rule rehearsal and guiding of actions and can foster the development of EF. Correlations with initial RW skills were also found. Such find can corroborate the idea that EF are required, among others, to remember information or pay attention to a task, with an important role in learning (Diamond, 2013; Lawson & Farah, 2015). Despite our correlational design, but based on literature (e.g., Dias et al., submitted; Lawson & Farah, 2015), we agree that EF support the cognitive operations underlying academic performance, for example facilitating keep information in mind while trying to read, inhibiting dis-tractors or wrong answers while decoding letters into sounds, or even trying alternative approach to tasks. Also, EF can enable the child to benefit from instruction, for example by allowing the child to pay attention in class and stay on task. This kind of learning-related behavior can facilitate learning. Both processes, EF as cognitive operations underlying academic performance or mediating learning-related behaviors, can explain the associations we have found. Probably, both different processes occur, the former better captured by the performance tests, the latter by the functional scale (Dias et al., submitted). Our results corroborate that, even in the stage prior to formal academic instruction, the EF is already associated with school readiness skills, which are predictors of future performance in the 1st grade of elementary education (Pazeto, 2016).Relationships were also observed between EF measures (tests and questionnaires) and behavioral indices. Considering the performance tests, correlations were consistent in indicating that children with higher scores in attention, CF and IC tests also tended to be better evaluated by their parents and teachers. The HD subscale was the one that established more correlations with indices of all EF evaluated, attention, CF, and IC. This finding receives support from the study of Schoemaker et al. (2013) that found an association between EF and externalizing behavior problems, also in preschool children. Furthermore, Diamond (2013) pointed out the relationship between the poor development of EF and behavioral characteristics of some disorders, including ADHD.The results are convergent when considering the functional measure of EF. That is, in general, the results suggest that better EF indices, independent of the respondent, are associated with better behavioral indices, also independent of the respondent. In accordance with the preceding discussion, the results highlighted a consistent association between the EF measures and the HD indicator. A point to be noted here refers to some negative correlations observed. Those established with the PSB indices were expected and indicated that children with greater difficulties in WM and CF tend to show less PSB. Previous evidence has already suggested a relationship between EF and social adjustment (Baptista et al., 2016). The negative correlations established with ES (with IC according to the teachers and IC and RG according to the parents) may suggest that high IC and/or high RG can be non-adaptive or dysfunctional. That

is, at high levels these skills could cause distress to the child. Future studies should investigate this matter further to define the nature of the relationship between these skills. It is possible to hypothesize that this correlation can be viewed as an inverted 'U' type curve, in that higher levels of IC and RG are functional to a certain point, from which they can become dysfunctional.In summary, the results show that EF are associated with other areas of child functioning, including relevant skills for school readiness, even before the entry into formal education. Based on these findings and on the literature of the area that defines the important role of EF for diverse outcomes (Diamond, 2013; Dias et al., submitted; Lawson & Farah, 2015; Moffitt et al., 2011; Schoemaker et al., 2013), it is essential to promote conditions for the evaluation and early identification of deficits in these skills. Studies should complement the present findings, particularly elucidating the directions of the relationships outlined here and indicating possible mediations between them.It should be highlighted the limited sample size and the relatively homogeneous characteristics of the sample (one private school and by convenience) among the limitations of this study. Thus, the results should be considered with caution when attempting to generalize to other samples, mainly for those from more disadvantaged socio-economic backgrounds. Furthermore, the study had a correlational design, which precludes any causal inference or direction of the relationships obtained. The study, however, included, besides performance tests, functional measures answered by two respondents, parents and teachers, providing a comprehensive panorama of child functioning. The study adds its contribution to the available knowledge regarding EF and their pattern of convergence with important childhood development skills.

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