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Socio-Economic Level and Executive Functioning: Vulnerability and Effects on Development

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Abstract

In recent years, Brazil has managed to increase its economic development. However, this development has not meant improved living conditions for most of the population, and this socioeconomic gap has grown in the Covid-19 period. The family socioeconomic level ends up influencing the access to resources such as health, education, and leisure. These resources are extremely important for cognitive development, especially the Executive Functions (EF). Neuroscientific findings highlight that the Executive Functions (EF) are those that suffer the most from the impact of unfavorable development conditions. The FE is responsible for the ability of self-regulation or self-management and its development represents an important adaptive milestone in the human species. In this study, 80 children regularly enrolled in public and private schools were evaluated, with the main objective of assessing executive functions using the NEPSY-II.

Keywords

Executive Functions, Nepsy-II, Vulnerability

1. Introduction

The last two years have been crossed by the biggest health crisis of this century. The Covid-19 pandemic has intensified the economic and social inequalities that characterize Brazil, forcing a discussion of the interface between poverty and development. The economic impact resulting from the pandemic was associated with restrictions on the functioning of various activities, in addition to social

distancing. This scenario affected both the consumption and the production of products and services, which, in turn, had a direct impact on the supply of labor, significantly increasing the unemployment rate in 2020. However, data show that groups designated as more vulnerable have disadvantages regarding the indicators of participation, unemployment, occupation and informality, reinforcing the occurrence of more severe economic impacts on this population (Brasil, 2005).

According to the National Policy of Social Assistance—PNAS (Brasil, 2005), contexts of vulnerability are associated above all with notions of inequality and social exclusion, going beyond the material sphere. This is a more unprotected stratum of the population, and poverty—initially understood as a condition of not having enough income to meet basic needs—is an element that contributes to social exclusion and to the configuration of socio vulnerable contexts that can impact the brain development and cognitive and emotional systems of children (Carvalho, 2017; Winter et al., 2020).

According to the National Household Sample Survey—PNADC, released by the Brazilian Institute of Geography and Statistics (IBGE), 29.6% of the country's total population are part of the so-called "Map of New Poverty". The study also highlights that in two years of the pandemic (2019 to 2021), 9.6 million people have fallen into poverty (FGV, 2022), with greater and severe losses being observed in social markers of socioeconomic class, race and gender (Aragão et al., 2022). The accumulation of risk factors associated with vulnerability contexts is more frequent in situations of poverty, in which the profile of families and communities is characterized by a less favorable socioeconomic level and by difficulties in accessing educational, social and health resources (Carvalho, 2017).

Recent research in the field of neuroscience reveals that the early life experience of poverty is related to several unfavorable long-term outcomes, such as low academic achievement and substance abuse (Antón-Toro et al., 2021; Quach et al., 2019), as well as neurodevelopmental impacts, notably involving the functioning of the prefrontal cortex. Furthermore, it is necessary to highlight the impact of contexts of vulnerability on the development and functioning of the prefrontal cortex. This has an extensive network of neural connections with various areas of the brain, including subcortical structures such as the amygdala and hippocampus, directly involved in the formation of memories and emotional regulation (Esperidião-Antonio et al., 2008). In this sense, developmental changes in critical phases of maturation and synaptogenesis of frontal brain areas can make children vulnerable to the emergence of learning difficulties.

In this context, studies report a significant relationship between poverty and the low performance of executive functions (EF), which are a group of cognitive processes that facilitate goal-oriented behavior and individual approaches to new situations. Among the core components of FE are inhibitory control, working memory, and cognitive flexibility (Rosen et al., 2019; Haft & Hoeft, 2017).

Inhibitory control refers to the ability to inhibit responses that the individual has a strong tendency to execute (prepotent responses) or in response to dis-

tracting stimuli, in other words, it is the ability to ignore unnecessary information or impulses for the performance of a determined activity (Miyake et al., 2000). This executive component can be understood as a complementary filtering mechanism to selective attention, inhibiting irrelevant stimuli to the solution of a given problem and thus minimizing the demand for information processing (Gazzaniga, Ivry, & Mangun, 2002).

Abnormalities associated with this skill are often associated with impulsive behavior. The subject's impulsiveness can be assessed by response-suppression tasks, such as the Go-No Go paradigm and the Stroop effect (the presentation of simultaneous information with conflictual meaning) and in tasks that measure reaction time (Fuentes et al., 2008).

Malloy-Diniz et al. (2010) complement the concept of inhibitory control with the division of the impulsive phenotype into two patterns: predominantly motor impulsivity and attentional impulsivity. In neuropsychological assessment, the first pattern is characterized by the emission of overbearing and thoughtless responses. In turn, the attentional pattern is distinguished by generating decontextualized and impulsive responses (Barros, 2014).

Inhibitory control skills show greater development during the preschool period than in later years, while working memory and cognitive flexibility develop in a more linear fashion throughout maturation (Barros, 2014; Best & Miller, 2010; Kolb et al., 2012). Such differences suggest that the age range of exposure to poverty contexts is a mediating factor in this relationship.

In this regard, weaknesses in the development of IC may be linked to early experiences of poverty, contributing to a higher risk of maladaptive outcomes. Recent review studies have found lower efficiency of inhibitory control in children who experienced poverty at an early age, with these impacts related to impaired academic performance and social competence (increased externalizing and internalizing behaviors) also present in the profile of this population (Allee-Herndon & Roberts, 2019; Taylor & Barch, 2022).

According to Lipina and Evers (2017), the findings on the influences of poverty on neural cognitive development were initially identified by applying three types of classic unidimensional measures: income, parental education, and occupation. Recent studies point out that family income is an important variable in the cognitive development of children being this influence at both anatomical and functional levels (Lawson, Hook, Hackman, & Farah, 2016; Noble et al., 2015), this may cause a major impact on the process of acquisition of academic skills (Blair & Raver, 2016; Corso, Sperb, Jou, & Salles, 2013; Lawson, Hook, HAckman, & Farah, 2016). Access to income presents itself as a significant variable, since it influences access to culture, education, health, and food (Guareschi et al., 2001), factors that are important for neurodevelopment and learning (Lawson, Hook, Hackman, & Farah, 2016).

Currently, there is a recognized effort to expand the understanding about the impacts of socioeconomic status (SES) on cognitive functions (Sbicigo et al., 2013). Recent studies have proven that the environment has a great influence on

the neuroplasticity process and consequently on neuronal communication, thus affecting the acquisition of specific cognitive skills. In this direction, evidence has been found that language development is negatively impacted by vulnerability conditions, notably those linked to socioeconomic status. Studies argue that in low-SES families the stimulation of oral production (speech) is lowered, which ends up generating compromises in the development of this skill (Engel de Abreu et al., 2015; Musso, 2010).

In Brazil, a survey conducted with 355 children living in São Paulo/SP and Salvador/BA, aimed to investigate the relationship between cognitive functioning and family socioeconomic level. The socioeconomic level was considered a latent variable estimated from three observed variables: education of parents or guardians, their occupation, and family income. The results showed that socioeconomic status was strongly associated with children's cognitive skills, especially executive functions, and language. Regarding executive functions, family income was the variable that had the most significant effect on the variability of their performance (Engel de Abreu et al., 2015).

According to the authors, this relationship is justified by the fact that income provides caregivers with the offer of a more enriched environment in terms of development through the possibility of greater access to financial resources, which subsidize investments in educational materials or activities (e.g., books and better quality of education), in addition to mitigating the probability of economic difficulties source of stressful situations in the home environment, since the developing brain is particularly sensitive to the prolonged effects of stress.

Amso and Lynn (2017) cohere this argument by extending this analysis to general child cognitive development. That is, they signal that households with more favorable socioeconomic status (higher parental education and family income) tend to have more access to enriching resources and varied opportunities to enhance children's cognitive development, such as interactions mediated by greater complexity in language, access to quality education, travel experiences, access to books, toys, social media, among other factors (Obradović & Willoughby, 2019).

In this direction, it is found that contexts of vulnerability and poverty during childhood, especially early in life, impact the development of an individual's executive functioning, and may present long-term effects that extend into adulthood. However, as discussed, distinct and independent underlying processes account for differences in specific domains (Fry et al., 2017), which makes this field of study winding and complex, especially considering that many aspects designated as risk factors may also constitute protective factors for child development.

From the above, one can conclude that there is a persistent need for further study in terms of circumscribing the neurodevelopmental mechanisms that link adversity experiences with school performance and social and economic context, which is the aim of this study. It is noteworthy that this information is essential

to subsidize effective early interventions aimed at enhancing child development whose course is located in contexts of vulnerability (McLaughlin et al., 2019).

2. Method

It is a correlational, cross-sectional and predominantly quantitative study. The sample is designed in a non-randomized method, with an open design and no group control. The study respects the guidelines and standards that regulate research involving human participants according to Resolution No. 466/2012 of the National Health Council, with the approval of the Research Ethics Committee of the Federal University of Rio Grande do Norte—CEP/UFRN (Report No. 221,596).

Therefore, all participants in this study were previously authorized by their respective parents/guardians.

2.1. Participants of the Survey

This study enrolled 80 children ranging between 5 and 8 years of both sexes. To allow a sensible developmental process evaluation of the participants, the sample was segmented in six-month intervals. Thus, it was possible to fill in the developmental continuum.

According to their ages, the students were divided into eight subgroups containing 10 participants each (n = 80). The participants belonged to 4 private and 3 government schools, both from the administrative regions (south and north) of the city of Natal, to comprehend a greater socioeconomic variety.

In the sample were included only children who were regularly enrolled in public or private schools in Natal, RN, after consent formally granted by parents/guardians. As inclusion criteria, only children without a clinical history of neurological injuries and/or dysfunctions, non-corrected hearing and visual deficits, or any motor dysfunctions that could affect the performance of the proposed activities were selected.

2.2. Instruments

As an instrument for data collection, it was used the Developmental Neuropsychological Battery (NEPSY-II) (Korkman, Kirk, & Kemp, 2007) second edition of the Developmental Assessment (Korkman, 1998), which was revised and expanded, making it sensitive to contemplate a wider age range (3 to 16 years) and filling the critical gap in the availability of pediatric neuropsychological assessment instruments.

The selection of this battery is based on the fact that it is considered accurate to assess the neuropsychological profile of children without neurodevelopment disorders, as well as the target audience in question. In addition, the battery is based on the clinical method of A. R. Luria, the proposition of functional systems, and clinical advances in Child Neuropsychology, which allows the presence of qualitative data from behavioral observations.

The NEPSY-II battery is composed of 27 subtests that assess the following functional domains: Attention/Executive Function, Language, Visual-Spatial Processing, Sensory-Motor Function, Learning, and Memory. For this study, the subtests of the domain "Attention/Executive Function" were selected, corresponding respectively to: Response Set; Drawing Fluency; Inhibiting Responses, and Producing Words.

2.3. Procedures

The procedures for data collection included the identification of the sample subjects based on the methodological design of the research (year and month of birth compared to the period of data collection and type of school registered). All children recruited performed the four subtests that make up the Attention and Executive Functions section of the battery, regardless of their age adaptation, to allow identification and understanding of developmental differences in task execution strategies.

The subtests were not applied in a fixed order, and thus a specific work plan was developed for each of the participating children, considering their engagement and motivation in the proposed activities. The subtests lasted approximately one hour and were conducted individually in a single session (in some cases it was necessary to have two sessions), which took place in the schools during school hours, in a quiet room with minimal distracting elements for the children.

3. Analysis

Statistical and inferential analyses of the data were performed using statistical software, and $p < 0.05$ was adopted as the level of significance in all analyses. The Kolmogorov-Smirnof test did not satisfy the normality hypothesis for the data ($p > 0.05$), but parametric measures were adopted due to the homogeneity of variances between groups, confirmed by the Levene test. This methodological choice is justified by the little influence of deviations from normality in samples larger than 30 subjects ($n > 30$) and the robustness of the tests performed.

The data analysis plan includes descriptive statistics of correct and incorrect answers in each subtest. Multivariate analysis of variance (MANOVA) was used to check for interaction effects between the independent variables (age and type of school), followed by univariate analysis of variance (ANOVA) to check for differences in performance between the independent variables.

Analysis by School Category

Univariate analysis of variance revealed significantly lower performance of public school students compared to private school participants' performance on the four subtests, with the following indices: Answer Set - omission errors [$F(1,79) = 4.75$; $p = 0.036$]; Drawing Fluency - total hits [$F(1,78) = 4.01$; $p = 0.049$]; Inhibiting Answers - errors in the Changes series [$F(1,72) = 351.35$; $p = 0.004$] and

Producing Words - Initial Letter series [F(1,79) = 130.05; $p = 0.027$].

Descriptive statistics for the subtests grouped by school type can be seen in Table 1, the subtests that had a significant difference by school type (private and public).

Regarding the time taken for the assessment, there was a significant difference ($p = 0.047$) with greater speed for the private school students. The private school participants completed the subtests in this study in the meantime of 60.82 seconds, while the public school students completed them in 65.80 seconds. This difference reveals a 7.9% increase in the total execution time of the activities.

In this comparison, it is worth mentioning the performance in Inhibiting Responses for the number of errors committed in the execution of the three subtest steps—an average of 4.82 more errors committed by public school children—and errors in the Changing step—4.39 more errors committed by public school participants. It is noteworthy that the Change step has a higher degree of complexity, since it requires the use of various cognitive skills such as attention, memory, and cognitive flexibility.

4. Discussion

The analysis of the performance of the subgroups revealed that there was a significant difference according to the variable Type of School (public or private), in the tasks that demand inhibitory control and conceptualization. The performance of public school students was significantly lower on these subtests. In addition, the children generated fewer graphical and phonetic elements in the fluency tasks. Vargens (2012) found similar results of lower performance among

Table 1. Descriptive statistics.

SCHOOL TYPE				
		Private n = 40	**Public n = 40**	***p***
Audition Attention and Response Set	Omission errors	**2.98 (±3.4)**	**5.181 (±5.5)**	**0.036***
Fluency in Drawing	Right answers - Structured phase	7.26 (±2.8)	6.05 (±3.0)	0.074
	Right answers - Arbitrary phase	7.77 (±4.3)	6.20 (±3.2)	0.068
	Total number of correct answers	**14.95 (±6.2)**	**12.25 (±5.6)**	**0.049***
Inhibiting Answers	Mistakes - Nomination	4.03 (±3.6)	4.40 (±3.6)	0.652
	Mistakes - Inhibition	9.21 (±7.7)	10.43 (±6.7)	0.462
	Mistakes - Changing	**11.64 (±5.02)**	**16.03 (±7.29)**	**0.004***
	Total number of mistakes	18.81 (±13.38)	23.63 (±13.13)	0.116
Phonological Processing	Right answers - Semantics	20.95 (±7.62)	18.63 (±4.96)	0.110
	Right answers - Initial letter	**7.63 (±5.4)**	**5.08 (±4.6)**	**0.027***

*Significant values.

public school children on the skills of selective attention, inhibitory control, and conceptualization. Lower ratings were also identified in the sample of this study, but do not represent a significant difference between school types.

It is noteworthy that the difference between public and private school was found in verbal subtests, except for the pictorial fluency score that comes from an executive task. The verbal subtests identified worse performance in public school children in inhibitory control and phonemic fluency. Such differences were not found in the semantic series (evocation of animals and food/drink). This data reinforces the need for evaluations that use non-verbal tasks to minimize the influence of language on their performance. According to Rosselli and Ardila (2003), the differences found in the results of non-verbal cognitive tests in different cultural contexts are the result of a complex interaction of brain, cultural organization and experience, and learning.

Considering these issues becomes essential since the context of vulnerability is present in the Brazilian context, and as the studies have recently shown, this is a reality in the whole world. The data found in the research corroborate the findings of Engel de Abreu et al. (2015). The existence of research conducted in different regions and realities but erupting in the same conclusion presents the eminent need to think about the impact of poverty on the development and learning process of children.

It is necessary to broaden the view to understand that the lack of access to quality health, food, and safety does not only generate biological issues, but cognitive and social issues of great impact.

Therefore, it is necessary to change the focus of the research conducted in the context of social vulnerability, so that future research aims to intervene and think about how to work to improve this reality and not to investigate this context. The impact of the context on cognitive functions and, consequently, in learning is already something concrete, and it is important to think about public policies that allow intervention and provide a better development of children.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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