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Improving Executive Functions in Elementary Schoolchildren

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Abstract: Executive Functions (EFs) describe a set of cognitive control abilities that help children to develop self-regulated behavior and do well in their schooling. The promotion of EFs in children at social risk is an area of relevance for neurosciences and education. On this basis, the present study set out to analyze a school-based intervention targeted to strengthening EFs in Argentine children at social risk. Participants were 69 children from 8 to 10 years old, from an urban-marginalized federal school in Mendoza. A quasi-experimental pre-test post-test design was used, with a control group. The cognitive intervention was embedded in the school curriculum and was carried out for a month and a half. The schoolchildren were evaluated before and after the intervention with EFs' neuropsychological tests. The main results showed that the group cognitive intervention was associated with gains in the schoolchildren's attention processes, although it did not favor other EFs, which could indicate moderate effectiveness. These data provide evidence in favor of ecological interventions as a way to promote attention development trajectories in children at social risk, and in turn, draw up guidelines to reflect on the design and the modalities of school-based interventions.

Keywords: *Executive functions, school-based intervention, children, socially-disadvantaged contexts.*

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Introduction

Executive functions (EFs) constitute one of the most significant cognitive predictors of school learning. Over the last 20 years, a body of research has documented its involvement in reading, writing, math skills, and science tasks (i.e. Best et al., 2011; Fuhs, et al., 2014; Welsh, et al., 2010). EFs enable self-regulating behavior and, consequently, play a critical role in the adjustment of children to the classroom context (Blair & Raver 2014; Diamond, 2012; Fritzpatrick, 2014).

The literature documents an academic gap between advantaged and disadvantaged children. In the attempt to identify factors that mediate the relationships between the environmental conditions of development contexts and school performance, neurosciences have identified executive functions as a mediating pathway. Research in developed countries (Crook & Evans, 2014; Fitzpatrick et al., 2014; Turner-Nesbitt et al., 2013) and in developing countries (Aran-Felippetti & Richaud de Minzi, 2011; Korzeniowski et al., 2016) have been able to document how the detriment of the material and socio-cultural conditions of the context of raising children impacts on the trajectories of the development of executive functions, and, in this way, affects children's school performance. Based on these studies, there is a growing interest in developing school-based interventions aimed at promoting executive functions in children from socially-disadvantaged contexts.

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Literature Review

Executive functions

Executive functions (EFs) are cognitive control processes that regulate thoughts, emotions and actions in sustaining goal-directed behavior or solving a problem (Barker et al., 2014; Diamond, 2013). They relate to a set of high-order cognitive processes involved in the self-regulation of behavior, and play a key role in children's cognitive, emotional, and social development.

Three core EFs have been identified: inhibitory control, working memory and cognitive flexibility (Miyake et al., 2000), from which more complex ones are built, such as planning, organization and metacognition. Inhibitory control is a multidimensional construct that involves mental operations aimed at suppressing inappropriate behavior, or an attention tendency towards irrelevant or distracting stimuli that can interfere with the deliberate resolution of a problem (Friedman & Miyake, 2004). Working memory refers to the ability to keep information online and manipulate it (Davidson et al., 2006; Diamond, 2013). In other words, working memory allows information to be maintained online and to operate on it, beyond distractions or despite carrying out another task. Finally, cognitive flexibility compromises the ability to shift attention from one perceptual paradigm to another, adapting mental activity and behavior according to the demands of the environment (Diamond, 2013; Fine et al., 2009).

Several authors identify attention control as an essential component of executive functions (Petersen & Posner, 2012; Portellano-Perez, 2005; Posner & Rothbart, 2014). Attention control is responsible for the organization and regulation of the cognitive processes involved in processing information in accordance with the situational requirement of the task (Ison et al., 2015). Attention control determines to which stimuli the attention resources will be directed, and is responsible for activating or inhibiting the processes involved in the efficient processing of information (Petersen & Posner, 2012). In its task of orchestrating the implementation of cognitive processes, attention control requires processes of attention effectiveness and efficiency. Attention effectiveness refers to the accuracy to focus and sustain voluntary attention towards the relevant aspects of the task while inhibiting the interference of distracting stimuli, during the period of time required to achieve the objective (Ison et al., 2015). Attention efficiency optimizes the focus and sustained attention processes using the minimum available time resources and, consequently, combines precision with perceptual speed (Monteoliva et al., 2014). In sum, attention is one of the cognitive control processes clearly relevant to cognitive performance and plays a key role in self-regulation processes (Posner & Rothbart, 2014).

The neuroanatomical substrate of EFs involves a set of interconnected neural networks that operate in a coordinated way across an integration zone located in prefrontal areas (Koechlin & Summerfield, 2007). EFs have a prolonged, multi-stage and sequential development, which is more intense during childhood, reduces its speed in early adolescence and continues until adulthood (Hughes, 2011; Korzeniowski et al., in press). The progressive development of EFs will enable: greater capacity to create mental schemas, greater mental flexibility, increase in the use and complexity of memory strategies, and greater organization and planning of cognitive and behavioral activity (Flores-Lazaro et al., 2014). These achievements will have a significant impact on children's school, social and emotional environment.

In the school environment, the adequate performance of EFs helps children to direct and sustain their attention on relevant aspects of tasks, and favor the maintenance and active manipulation of learning contents in memory. In addition, they are involved in: organizing school tasks, contributing to monitoring and reflection on learning processes, and promoting emotional self-regulation and the ability to develop effective strategies to face novel tasks or changing situations. For these reasons, EFs play a critical role both in learning tasks and for children's adjustment in the elementary classroom setting (Fritzpatrick, 2014).

The literature documents that EFs are predictors of school performance, from preschool to adulthood (i.e. Best et al., 2010; Welsh et al., 2011). In order to strengthen early learning-facilitating cognitive resources, much of the research has focused on designing and applying interventions to promote EFs in the early stages of the school life (i.e. Diamond et al., 2007; Rothlisberger et al., 2012). A lot fewer studies have been done in middle childhood (Diamond, 2012).

At the educational level, middle childhood presents schoolchildren with the learning of complex and demanding school competences, such as: text comprehension, problem solving, argumentative text writing, hypothesis comprehension and elaboration, and construction of inferences. The acquisition and mastery of these competencies will require a good performance of EFs. At the level of cognitive development, middle childhood is a stage in which sensitive periods have been identified in the evolutionary trajectory of EFs, one of greater intensity between 6 and 8 years of age, and, another, between 10 and 12 years of age (Davidson et al., 2006; Hughes, 2011). Therefore, middle childhood presents windows of opportunity to implement cognitive interventions aimed at strengthening cognitive control processes in children. Furthermore, the close correlations between EFs and school performance documented at this stage of development (Best et al., 2011; Welsh et al., 2010) can create an optimal time to transfer the cognitive gains associated with cognitive training to children's school performance.

Executive functions and socially-vulnerable contexts

Social vulnerability is a risky social condition that makes it difficult, in the present or future, to satisfy well-being in terms of subsistence and quality of life. It is a complex, multi-causal phenomenon that includes aspects such as helplessness, insecurity, exposure to risks and stress due to traumatic socioeconomic events, but it also involves, to deal with these events, the availability of resources and strategies that may arise from within the group itself or of external support (Golovanesky, 2007). Consequently, social vulnerability can be defined as: exposure to a risk, plus the ability to face it.

Studies have documented that children growing up in contexts of social vulnerability are exposed to numerous risk factors that impact their cognitive, affective and social development (Hackman & Farah., 2009; Lipina et al., 2011; Noble & Farah, 2013). In relation to cognitive development, a pioneering study identified EFs as one of the cognitive systems most sensitive to environmental experience (Noble et al., 2005) and, in recent decades, a body of literature, in "developed countries" (i.e. Crook & Evans, 2014; Fitzpatrick et al., 2014; Hackman et al., 2010) document that children growing up in socially-disadvantaged conditions perform less well in EFs compared to children growing up in socially-favored contexts.

Latin American studies coincide with these findings, and report, for children from disadvantaged contexts, in comparison to their peers from more advantageous social contexts, a lower performance in: attention, working memory, cognitive flexibility, planning, overcoming difficulties in self-regulating emotions and resolving conflicts (i.e. Ison, et al., 2015; Piccolo et al., 2016; Lipina et al., 2011; Musso, 2010). Likewise, slower trajectories of development of EFs have been recorded in children from deprived conditions (Aran-Filippetti & Richaud de Minzi, 2012). Difficulties in self-regulation abilities in childhood are associated with a higher incidence of: behavior problems, poor school performance, lower well-being and health. Such difficulties in childhood are linked with risks for a lower quality of life, lower academic achievement, lower employment status and conduct disorders, in adolescence and adulthood (Diamond, 2012; Fritzpatrick, 2014).

Based on these reports, over the last 15 years there has been increasing interest in the design and implementation of intervention programs aimed at stimulating the development of cognitive functions in children from disadvantaged socioeconomic contexts (Blair & Raver, 2014; Diamond & Ling, 2016; Hackman et al., 2010). The literature reviews encouraging results, indicating that these capacities can be strengthened with practice.

Experiences carried out in "developed" countries (Blair & Raver, 2014; Diamond et al., 2007; Raver & Blair, 2018; Rothlisberger et al., 2012; Walk et al., 2018) and "developing" countries (Goldin et al., 2014; Ison, 2009, 2011; Korzeniowski et al., 2017; Lipina et al., 2011; Richard´s et al., 2014; Segretin et al., 2014) document an improvement in attention tasks, inhibitory control, working memory, planning, cognitive flexibility, metacognition, problem solving, and verbal and graphic fluency, in children who have participated in programs or activities of cognitive stimulation.

Review studies show that children with the lowest performance in EFs are those who benefit most from cognitive stimulation interventions, and that enrichment is greater in the most demanding cognitive tasks, as required for the use of cognitive flexibility and working memory (Diamond, 2012; Diamond & Ling, 2016).

Different modalities of intervention have been used. Among them are curricular adaptations (i.e. "Tools of the Mind", Diamond et al., 2007), which consist of enriching the school curriculum with activities, games and tasks designed to stimulate children's self-regulatory capacities. Such interventions denote a greater ecological validity, and they have the advantage that they can be applied to a larger number of children, with appropriately trained teachers applying the intervention strategies. Review studies indicate that these types of interventions are effective in transferring children's cognitive gains to other areas of child development, such as school skills (Diamond & Ling, 2016). Despite their extensive benefits, specialized curricula have been tested in young children (3 to 6 years), with little or no application to middle-school children (Diamond, 2012).

In sum, school-based cognitive interventions targeted to improve EFs are framed from the perspective of strengthening resources, as a way of increasing the possibilities of children to face the risks implied by socially-disadvantaged conditions. Therefore, enriching children's classroom practices with activities to promote their cognitive development can be a valuable tool that can compensate for, or at least reduce, the persistent academic and sociocultural gap associated with socially-disadvantaged conditions.

Methodology

Research Goal

Assess the effectiveness of a school-based intervention aimed at strengthening executive functions — specifically attention control, inhibitory control and working memory — in Argentine children from socially-disadvantaged contexts.

Design and Participants:

A quantitative approach was used. The type of study was explanatory, and the design was "quasi-experimental, pre-test, post-test, with control group".

An intentional non-probability sample was used, which consisted of 69 children from 8 to 10 years of age (M = 8.64, SD = .64), of whom 51% were girls and 49% were boys. Schoolchildren were in their primary studies (3rd grade = 47% and 4th grade = 53%) in an urban-marginalized school in the province of Mendoza, Argentina. The schoolchildren were from a social-vulnerability context. The inclusion criterion was that the parents of the children have given their informed consent, guaranteeing the participation of their children in the research study. Two exclusion criteria were considered, being that children must not present: a) previously diagnosed neurological, psychiatric or psychological problems; and, b) two or more years of over-aged schooling.

Two groups were formed, one intervention and the other control. The intervention group (IG) was made up of 27 schoolchildren: 11 boys and 16 girls, the mean age of 8.78 years (SD = .70), 37% in 3rd grade and 67% 4th grade. The control group (CG) was made up of 42 schoolchildren: 18 were boys and 24 girls, the mean age of 8.56 years (SD = .59), 54% in 3rd grade and 47% in 4th grade. There were no differences in the sociodemographic conformation of the groups in the variables: age ($t_{(66)}$ = -1.14, p = .162), sex (X^2 = 1.29, p = .187) and grade (X^2 = 1.81, p = .137).

Materials and Instruments:

Perceptions of Differences Test (*FACES*, Thurstone & Yela, 2012). It is a neuropsychological test that evaluates focus and sustained attention. It consists of 60 stimulus blocks, each consisting of three schematic drawings of faces (with elementary lines representing the mouth, eyes, eyebrows and hair), one of which is different. The task is to determine which face is the different and to cross it out. The test is applicable from 6-7 years onwards. In this study, the indicators proposed by Monteoliva et al. (2014) were used, integrating the concept of attention performance: attention effectiveness (EA), attention efficiency (AF) and attention performance (AP). In addition, the Impulsivity Control Index (ICI) proposed by Crespo-Eguilaz et al. (2006) was used. The ICI measures the capacity to avoid random or reiterative responses in a visual searching task. The test exhibits excellent psychometric properties for schoolchildren of Mendoza (test-retest reliability: *rho* = .87, Carrada, 2011) and norms are available for children from 7 to 12 years old, according to age and type of school: urban, and urban-marginalized (Carrada, 2011; Monteoliva et al., 2017).

Rings Test (Monteoliva et al., 2016): This instrument assesses the processes of effectiveness, efficiency and attention performance, and has the particularity of using Ladolt's C optotype as a visual stimulus, an optic used mainly in the ophthalmological field, as a visual stimulus. The construction and design of this test was guided taking, as a reference test, the Perception of Differences Test or FACES Test (Monteoliva et al., 2013, 2016; Santillan et al., 2013). The distribution of the stimuli is organized in 60 blocks each, with triads of optotypes, where two stimuli are the same and one different. The subject's task is to find this difference and cross it out. The size of the target stimulus was the result of measurements of the visual size subtended in the details of the reference test (faces, eyes, eyebrows and hair), and their average (Monteoliva et al., 2013, 2016; Santillan et al., 2013). The test presented adequate psychometric properties for the sample in studies: test-retest reliability (r = .68, p <.001) and convergent validity with the FACES Test (r =. 59, p <.001).

Stroop, Color and Word Test (Golden, 2005): This is a neuropsychological test that evaluates interference control in a conflict resolution task. It provides a measure of interference resistance, which has been associated with inhibitory control, attention control, focused attention and working memory (i.e. Rueda, Posner, & Rothbart, 2005). The interference resistance score ranges from negative to positive values. Negative scores indicate difficulty with controlling irrelevant stimuli interference (Golden, 2005). It is administered individually from the age of seven onwards, and its approximate duration is five minutes (Golden, 2005). This instrument is reliable, presenting a high internal consistency (alpha = .89, Golden, 2005).

Auditory Working Memory Test, Battery III COG Woodcock-Munoz (Munoz-Sandoval et al., 2005): This subtest assesses working memory. The task is to keep a sequence of numbers and words active in memory, while dividing it into two groups. This is in order to express the sequence numbers in ascending order first, and then the words. The instrument is for individual application, and can be administered from 3 to 80 years of age. The average reliability of the instrument is *rho* = .80 (Munoz-Sandoval et al., 2005).

Cognitive intervention program (Korzeniowski et al., 2017): A shortened version of the executive function training program for children was applied (Korzeniowski et al., 2017). The cognitive training program was divided into 12 sessions. Each session used a combination of increasingly difficult activities and games to stimulate different cognitive control functions in the same session. These activities included: crossing out numbers or letters, searching for differences, listening attentively, ruling games, ordering cartoon sequences, completing sequences, solving problems, classifying tasks, doing divided attention exercises and playing cognitive interference games. The program was inserted into the school curriculum with a biweekly frequency, and was applied to the entire group of schoolchildren during the period of one-and-a-half months.

Procedure

A series of steps were carried out to fulfill the objectives of the study. First, the authorities of the participating educational institution were contacted in order to state the objectives of the research and request their authorization to carry it out. Secondly, there was a dialogue with the grade-level teachers to present the project's objectives, agree on time and work space with their students, taking into account that the evaluation / stimulation activities are carried out at times when they do not interrupt significant stages of the children's learning processes. Then, a note was sent to the parents of the children, in which the purposes of the research were expressed and their informed consent was requested, authorizing the participation of their children in the research. The authorized children were invited to participate, and their verbal assent was requested to carry out the proposed activities, after explanation that their participation is voluntary, anonymous and able to be declined whenever they wish.

Subsequently, the pre-intervention evaluation of the students was carried out, in which the FACES Test and Rings Test was applied in a group session. Then, in two individual sessions of 20 minutes each, the executive function tests were administered. The IG then received the group cognitive intervention for a month and a half. Finally, the post-test evaluation was carried out, using the same instruments as in the pre-test stage.

The instruments and the intervention program were applied by psychologists and advanced psychology students, duly-trained for this purpose. After performing the data analysis, a report on the results obtained was provided to the educational institution.

Data Analysis:

The following statistical procedures were conducted to obtain the results. First, the pattern of lost cases was analyzed using the SPSS .23 Lost Value Analysis routine. Then, the presence of outlier cases was examined by calculating standard scores for each variable. Compliance with the assumptions of univariate normality was examined using the asymmetry and kurtosis indices of the variables under study. To respond to the objective of the work, multiple comparisons were made with non-parametric tests (Mann Whitney U and Kruskal Wallis), to assess whether the cognitive performance of children fluctuated depending on the control / intervention group, age and gender in the pretest. Subsequently, the effectiveness of the intervention was assessed. For this purpose, intragroup comparisons (Wilcoxon signed rank test for related samples) and intergroup comparisons (Mann Whitney U test for independent samples) were performed, with a significance level of .05. The magnitude of the differences was estimated using biserial correlation index (Dominguez-Lara, 2017) and the Cohen's criteria (Cohen, 1988) was employed to interpreted them.

Ethical aspects:

For the development of this project, the ethical guidelines and the code of conduct for psychologists, established by the American Psychological Association (2002), were taken into account. This implies: that the parents or guardians of the participating children will be duly informed regarding the objectives of the study and the voluntary nature of participation in the study, and their informed consent authorizing the participation of their children will be required. Likewise, each child must give their verbal consent to participate in the research study. The privacy and confidentiality of all information will be respected.

Results

Pre-intervention comparative study

In the pre-intervention, there was analysis of whether the performance of executive functions fluctuated according to age, gender, school grade and control / intervention group.

Regarding sociodemographic variables, no significant differences were found in the children's cognitive performance. In other words, the results indicated that performance in attention, inhibitory control and working memory did not fluctuate in relation to gender ($p > .05$), age ($p > .05$) and grade level ($p > .05$) of the participating children.

Following this, cognitive performance was compared between the children making up the control group and those in the intervention group. The results indicated that the control group children showed a better performance in attention efficiency in the two visual search tests (Faces: $U = 358.00$, $p = .017$; Rings: $U = 227.00$, $p < .001$) and in attention performance in the Rings Test ($U = 306.50$, $p = .005$), compared to the intervention group. Likewise, the children in the control group performed the two visual search tests more quickly (Faces: $U = 306.00$, $p = .002$; Rings: $U = 267.50$, $p = .001$), compared to their peers in the intervention group. The means and standard deviations can be seen in Table 1.

In working memory and interference control, both groups presented a similar baseline (see Table 1).

Table 1. Differences in executive functions between control group and intervention group in the pre-test

Variable	CG			IG				
	n	*M*	*DS*	*n*	*M*	*DS*	*U*	*p*
Interference Control (Stroop Test)	32	-1.35	6.89	27	-2.21	6.41	215.00	.710
Working Auditory Memory	32	17.61	5.49	26	18.72	7.83	312.50	.604
FACES Test								
Execution Time	42	577.69	164.09	26	722.58	214.60	**306.00**	**.002**
ICI	42	75.99	27.94	26	76.11	33.78	555.00	.960
Attention Effectiveness	42	0.88	0.14	26	0.88	0.17	553.50	.945
Attention Efficiency	42	0.10	0.03	26	0.08	0.03	**358.00**	**.017**
Attention Performance	42	0.25	0.04	26	0.24	0.05	432.50	.148
Rings Test								
Execution Time	39	322.18	90.59	26	426.50	134.04	**267.50**	**.001**
ICI	39	74.87	24.11	26	60.20	39.79	419.50	.240
Attention Effectiveness	39	0.88	0.12	26	0.80	0.20	429.00	.231
Attention Efficiency	39	0.17	0.04	26	0.13	0.06	**227.00**	**<.001**
Attention Performance	39	0.28	0.04	26	0.24	0.06	**306.50**	**.005**

Note: ICI: Impulsivity Control Index.

Post-intervention comparative study

Two comparative studies were conducted to assess the efficacy of cognitive intervention: one intragroup and the other intergroup.

Intragroup comparative study

The pre-test and post-test comparison in the intervention group (IG) indicated that the children showed better attention performance (see Table 2). This improvement was recorded in the two visual search tasks performed by the children (FACES Test and Rings Test), supporting the results found. In the post-test, the IG children presented improvement in: impulsivity control (Faces: Z = -3.03, p = .002, r_{bis} = .61; Rings: Z = -2.46, p = .014, r_{bis} = .51), attention effectiveness (Rings: Z = -2.40, p = .017, r_{bis} = .50), attention efficiency (Faces: Z = -3.77, p = <.001, r_{bis} = .75; Rings: Z = -3.07, p = .002, r_{bis} = .64) and attention performance (Faces: Z = -2.97, p = .003, r_{bis} = .59), compared to the pretest. Likewise, it was recorded that the children used a smaller amount of time in the execution of the FACES Test (Z = -3.88, p = <.001, r_{bis} = .78) and of the Rings Test (Z = -2.26, p = .004, r_{bis} = .47) in the post-test, compared to its baseline. The effect sizes of the differences oscillated between .47 to .78, which indicate that the attention improvements were relevant in the post-test.

Table 2. Pre-test and post-test differences in executive functions in the intervention group.

Variable		Pre-test		Post-test				
	n	*M*	*DS*	*M*	*DS*	*Z*	*p*	r_{bis}
Interference Control (Stroop Test)	27	-2.21	6.41	3.40	3.53	-.235	.814	.05
Working Auditory Memory	26	17.69	7.68	19.06	4.86	-.775	.450	.15
FACES Test								
Execution Time	25	722.58	214.60	505.24	17616	**-3.88**	**<.001**	**.78**
ICI	25	76.11	33.78	77.74	36.96	**-3.03**	**.002**	**.61**
Attention Effectiveness	25	0.88	0.17	0.89	0.18	-1.04	.297	.21
Attention Efficiency	25	0.08	0.03	0.12	0.04	**-3.77**	**<.001**	**.75**
Attention Performance	25	0.24	0.05	0.26	0.06	**-2.97**	**.003**	**.59**

Table 2. Continued

Variable	***n***	**Pre-test**		**Post-test**		***Z***	***p***	r_{bis}
		M	***DS***	***M***	***DS***			
Rings Test								
Execution Time	23	426.50	134.04	348.57	170.06	**-2.26**	**-.024**	**.47**
ICI	23	60.20	39.79	70.00	35.49	**-2.46**	**.014**	**.51**
Attention Effectiveness	23	0.80	0.20	0.85	0.18	**-2.40**	**.017**	**.50**
Attention Efficiency	23	0.13	0.06	0.17	0.07	**-3.07**	**.002**	**.64**
Attention Performance	23	0.24	0.06	0.27	0.06	-1.86	.062	.39

Note: ICI: Impulsivity Control Index.

In the other executive functions, interference control (Z = -.235, p = .814, r_{bis} = .05) and auditory working memory (Z = .775, p = .450, r_{bis} = .15), there were no pre-test – post-test differences in the IG (see Table 2).

The pre-test and post-test comparison in the CG indicated that the children showed better attention performance (see Table 4). This improvement was recorded in the two visual search tasks performed by the children (FACES Test and Rings Test). In the post-test the CG children presented improvement in: impulsivity control (Faces: Z = -3.28, p = .001, r_{bis} = .51; Rings: Z = -3.07, p = .002, r_{bis} =.49), attention effectiveness (Faces: Z = -3.28, p = .001, r_{bis} = .51; Rings: Z = -2.56, p = .010, r_{bis} = .49), attention efficiency (Faces: Z = -4.29, p = <.001, r_{bis} = .66; Rings: Z = -3.84, p = <.001, r_{bis} = .59) and attention performance (Faces: Z = -4.59, p = <.001, r_{bis} = .79), compared to the pre-test. Likewise, it was recorded that the group spent a lesser amount of time in the execution of the FACES Test (Z = -3.47, p = <.001, r_{bis} = .54) and the Rings Test (Z = -2.66, p = .008, r_{bis} = .43) in the post-test, compared to its baseline. The effect sizes of the differences oscillate between .41 to .71, which indicate that the attention improvements were relevant in the post-test.

Table 3. Pre-test and post-test differences in executive functions in the control group.

Variable	***n***	**Pre-test**		**Post-test**		***Z***	***p***	r_{bis}
		M	***DS***	***M***	***DS***			
Interference Control (Stroop Test)	32	-1.35	6.89	1.13	8.18	-.654	.513	.12
Working Auditory Memory	32	17.42	5.58	18.69	4.85	-.976	.329	.17
FACES Test								
Execution Time	42	577.69	164.09	469.43	144.09	**-3.47**	**.001**	**.54**
ICI	42	75.99	27.94	82.75	21.36	**-3.28**	**.001**	**.51**
Attention Effectiveness	42	0.88	0.14	0.91	0.11	**-3.28**	**.001**	**.51**
Attention Efficiency	42	0.10	0.03	0.13	0.04	**-4.29**	**<.001**	**.66**
Attention Performance	42	0.25	0.04	0.27	0.04	**-4.58**	**<.001**	**.71**
Rings Test								
Execution Time	39	322.18	90.59	283.30	77.21	**-2.66**	**.008**	**.43**
ICI	39	74.87	24.11	79.75	23.46	**-3.07**	**.002**	**.49**
Attention Effectiveness	39	0.88	0.12	0.90	0.12	**-2.56**	**.010**	**.41**
Attention Efficiency	39	0.17	0.04	0.20	0.06	**-3.84**	**<.001**	**.59**
Attention Performance	39	0.28	0.04	0.29	0.04	-.719	.062	.11

Note: ICI: Impulsivity Control Index.

Finally, it was observed that in interference control (Z = -.654, p = .513, r_{bis} = .12) and auditory working memory (Z = -.976, p = .329, r_{bis} = .17), no pre-test – post-test differences were recorded in the CG (see Table 3).

Post-intervention intergroup comparisons

The cognitive performance of the children who participated in the cognitive intervention was compared with the control group after the intervention. The results indicated that both groups presented similar performance in interference control, auditory working memory and attention performance (see Table 4).

Table 4. Differences in executive functions between control group and intervention group in the post-test.

Variable	CG			IG				
	n	***M***	***DS***	***n***	***M***	***DS***	***U***	***p***
Interference Control (Stroop Test)	32	1.13	8.18	27	3.40	3.53	223.50	.201
Working Auditory Memory	32	18.86	4.89	26	19.24	4.76	289.50	.641
FACES Test								
Execution Time	42	469.43	144.09	25	505.24	176.16	472.00	.492
ICI	42	82.75	21.36	25	77.74	36.96	519.00	.852
Attention Effectiveness	42	0.91	0.11	25	0.89	0.18	523.00	.852
Attention Efficiency	42	0.13	0.04	25	0.12	0.04	488.00	.630
Attention Performance	42	0.27	0.06	25	0.26	0.04	488.00	.629
Rings Test								
Execution Time	39	283.30	77.21	23	348.57	170.06	395.00	.181
ICI	39	79.75	23.46	23	70.00	35.49	391.00	.162
Attention Effectiveness	39	0.90	0.12	23	0.85	0.18	393.50	.217
Attention Efficiency	39	0.20	0.06	23	0.17	0.07	346.50	.061
Attention Performance	39	0.29	0.04	23	0.27	0.06	356.00	.080

Note: ICI: Impulsivity Control Index.

It is important to update that, in the pre-intervention stage, the control group presented a better attention performance than the intervention group. However, in the post-intervention stage, these differences were blurred. These results, together with those obtained in the previously described intra-test pretest-post-test studies, indicate two interesting findings. On the one hand, they indicate that both the CG (r_{bis} = from .41 a .71) and the IG (r_{bis} = from .47 a .78) showed greater improvement in their attention performance compared to their baseline, which can be related to the effect of maturation, as the evaluations were carried out six months apart. On the other hand, the IG registered a greater gain in attention performance than the control group, especially in the speed of solving the visual tasks (Execution time: FACES Test: r_{bis} = .78 vs. r = .54; Rings Test: r_{bis} = .47 vs. r_{bis} = .43), attention efficiency (FACES Test: r_{bis} = .75 vs. r = .66; Rings Test: r_{bis} = .64 vs. r_{bis} = .59) and impulsivity control (FACES Test: r_{bis} = .61 vs. r_{bis} = .51; Rings Test: r_{bis} = .51 vs. r_{bis} = .49). These improvements allowed IG to reach the performance of the control group and compensate for the initial differences. This last fact could indicate that the cognitive intervention favored the development of the attention capacity in the children who participated in the experience. Figures 1 to 4 illustrate the findings mentioned.

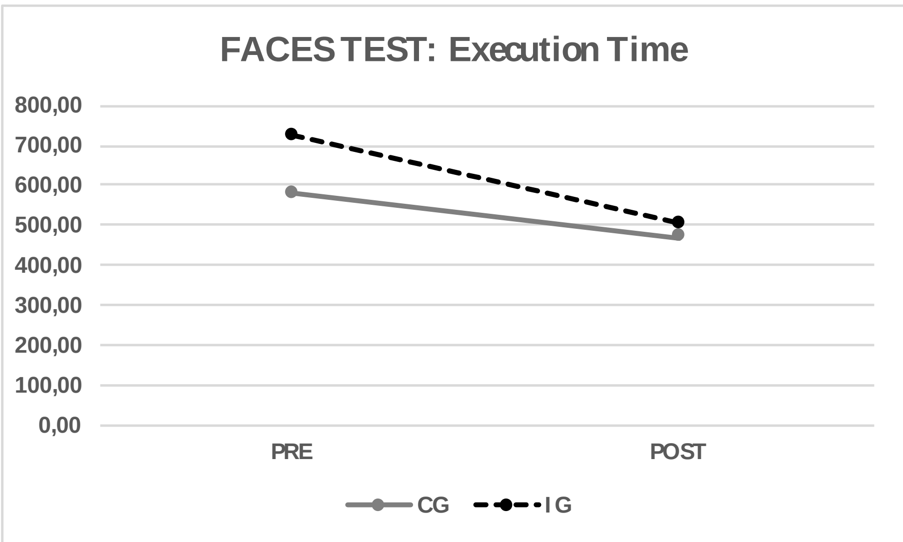

Figure 1. Pre-test and post-test differences in FACES Test execution time, between IG and CG.

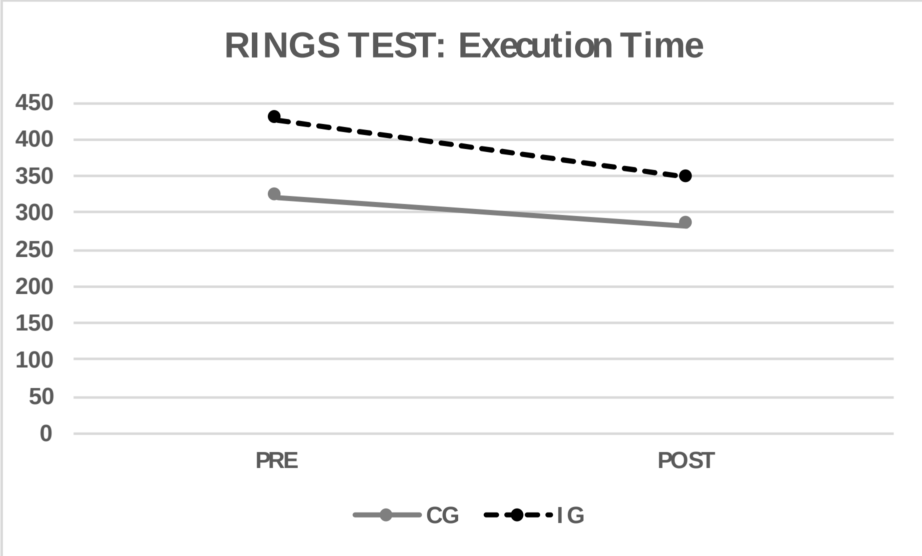

Figure 2. *Pre-test and post-test differences in Rings Test execution time, between IG and CG.*

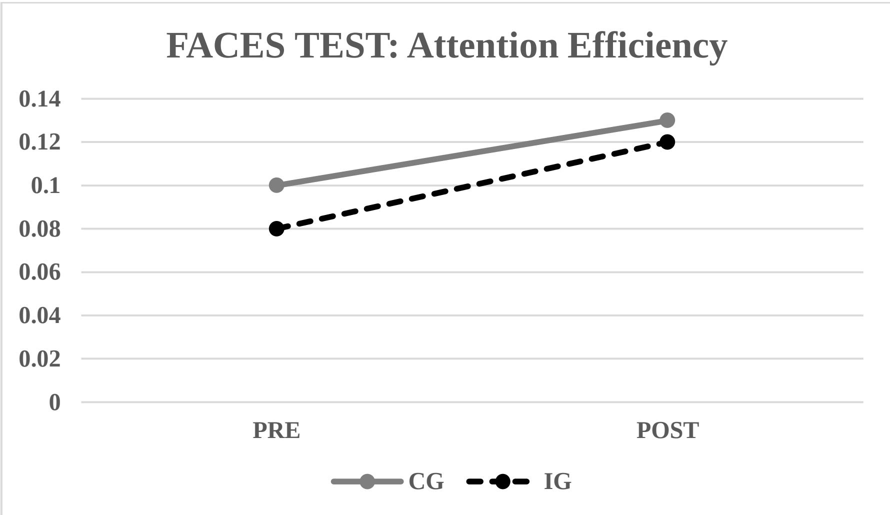

Figure 3. *Pre-test and post-test differences in FACES Test attention efficiency, between IG and CG.*

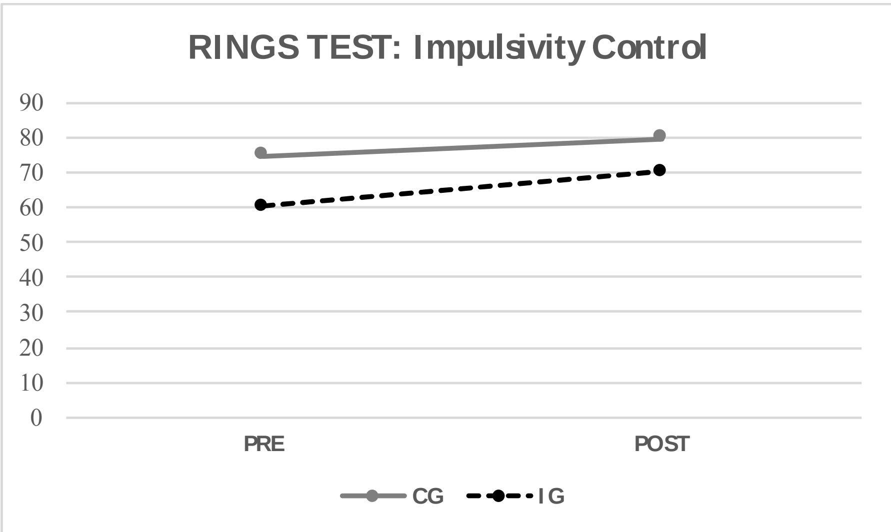

Figure 4. *Pre-test and post-test differences in RINGS Test impulsivity control, between IG and CG.*

Discussion

The present study set out to assess the effectiveness of a cognitive intervention program embedded in the school curriculum, aimed at promoting executive functions in schoolchildren from socially-disadvantaged contexts. The results obtained indicated a moderate effectiveness of the intervention program, which was associated with an improvement in attention performance.

The children who participated in the experience had a better performance in attention efficiency, attention performance and impulsivity control compared to their baseline. Children who did not participate in the experience also presented a similar improvement. A first reading of these results could indicate that the gains in attention capacity of both groups could be associated with the evolutionary development of attention. It is important to update that six months elapsed from the pre-test assessment to the post-test assessment. These results are in line with others that have reported improvements in attention performance in children from 8 to 10 years of age (Ison, 2009, 2011; Monteoliva et al., 2017).

Analyzing the development trajectories of both groups, a point of interest is observed. In the pre-intervention stage, the CG children outperformed the IG children in attention efficiency and in the speed of executing the both visual tasks. It was observed that the CG children carried out the two proposed visual search tasks more quickly and, consequently, were more efficient at selecting the relevant stimuli. Although both groups improved their performance six months later, the differences between CG and IG were blurred in this second evaluation, which could indicate a greater gain in IG in their attention span, which allowed them to compensate for the initial differences with their controls. These results are strengthened by comparing the magnitude of the improvement in attention between the children who participated in the intervention and the ones who did not participated. The comparison of the differences between post-test and pre-test for each group showed greater improvements in the IG than the CG in attention, especially in attention efficiency and impulsivity control (ICI). In this sense, it could be pointed out that the intervention acted as a factor that potentiated the trajectory of development of attention capacity in the children who participated in the experience.

Attention efficiency and impulsivity control were the attention processes in which the greatest advances were recorded. Attention efficiency process make it possible to differentiate those children who, with the same level of attention effectiveness, differ from each other in the speed of processing the stimuli. It is appropriate to update that attention effectiveness (AE) allows evaluating the accuracy with which a child discriminates stimuli within a set of similar patterns over a long period of time (Monteoliva et al., 2017). In contrast, attention efficiency (AF) refers to the cognitive ability to regulate and optimize the attention mechanism to select and maintain attention over an extended period of time, using the minimum available time resources (Monteoliva et al., 2013).

On the other hand, impulsivity control refers to the capacity to stop and think when choosing the target stimuli from a pool of distractors. It allows children to focus attention and avoid random or reiterative answers in a visual attention task (Crespo-Eguilaz et al., 2006). The IG showed greater gains in impulsivity control than the CG, which could indicate that the intervention favored the children's capacity to focus and sustain their attention on the task's requirements, while inhibiting impulsive responses.

Therefore, IG children showed greater gains in attention processes that involve not only precision in attention processes of focus and sustainment, but also in the speed of accurately processing stimuli relevant to the task. In sum, these results are in line with other international research (Karabach, 2015; Moreno et al., 2018; Rabiner et al., 2010; Ramos et al., 2017; Rueda et al., 2005; Sarzynska et al., 2017; Walk et al., 2018) and national studies (Ison, 2009, 2011; Ison et al., 2017; Segretin et al., 2014), which point out that cognitive stimulation programs, applied systematically and in moderate periods of time, are associated with improvements in children's attention performance.

The applied intervention program was not effective in improving auditory working memory and interference control. Some possible explanations for this fact can be related to the group modality of the program, the frequency of application and its duration. The program was inserted into the school curriculum, and applied to the entire group of schoolchildren in the classroom. Although this modality provides ecological validity to the intervention, and can favor more children during a shorter period of time, working with the entire group of schoolchildren makes it more difficult to scaffold each child's individual cognitive progress, such as auditory working memory and interference control. Consistent with this observation, other studies have reported the greater effectiveness of small-group compared to full-group interventions in children at social risk (Raver & Blair, 2018; Rothlisberger et al., 2012). One way to compensate for this difficulty could have been to extend the period of the intervention; however, due to school times and requirements, this was not possible. Applying the intervention for only a month-and-a-half could have been a negative factor regarding strengthening the other EFs. Systematic and sustained application over time is one of the most important keys to the success of this type of intervention (Diamond & Ling, 2016). The difficulties mentioned are associated with the challenges that ecological interventions imply in natural contexts of children's development. Future studies are expected to contribute to improving the design and application format of these valuable school-based intervention resources.

In summary, it is considered that the main contribution of this work is the application of an ecological intervention device favoring attention development in the participating children. The development of attention is essential for the functioning of other socio-cognitive processes, and is one of the factors that plays a central role in the learning processes that are proposed at school. The attention to the learned material facilitates its cognitive processing, its storage and its memory recovery, allowing content updating when the situation requires it (Ison et al., 2015). Consequently, its promotion in children from disadvantaged contexts is a way of strengthening cognitive resources associated with good school performance.

Conclusion

The promotion of cognitive resources in children growing up in conditions of social vulnerability is an area of relevance for neurosciences and education, as it constitutes a way of addressing the academic and socio-cultural gap between the most- and least-favored children. Consequently, in recent decades, this has focused on the design and application of interventions that promote such resources (Blair & Raver, 2014; Diamond & Ling, 2016). The present study is framed within this challenge, and provides new evidence in favor of ecological interventions, indicating that cognitive stimulation activities inserted within the school curriculum favor the cognitive development of children.

The results found indicated that the program in its group modality was associated with gains in the children's attention processes, although it did not favor other cognitive control abilities, which could indicate moderate effectiveness. This provides guidelines for reflecting on the design and modality of intervention programs in the school context and allows two conclusions to be reached. One, group interventions that respect the natural makeup of school groups show greater ecological validity, but require to be applied more frequently and with a sustained duration over time, in order to consolidate the improvements observed. Two, small group interventions may be more appropriate in children at social risk, as they allow for a better adjustment to the disparities in the executive functions performance of children associated with different maturational and sociocultural factors. Future studies are necessary with a view to contrasting different types of interventions and contributing to the development of effective strategies for the promotion of cognitive resources in children at social risk.

Suggestions

The results indicated a moderate effectiveness of the school-based intervention, so it would be of interest that future studies improve the design of the intervention adjusting its duration and modality. It is suggested to apply the intervention for a longer period of time (6 to 8 months), and to carry out with small groups of schoolchildren. Likewise, it is interesting to continue testing school-based interventions aimed at promoting EFs in Latin American elementary schoolchildren from socially disadvantaged contexts, due to the lack of studies in the area. Future studies could incorporate the promotion of more complex EFs such as planning, metacognition, monitoring. It would be of interest if other studies would consider the generalization of cognitive achievements associated with the intervention to other areas of child development, such as school performance, peer relationships, etc. Finally, it would be desirable for future interventions to train educators in the design of teaching sequences aimed at promoting students' EFs, in order to provide greater ecological validity to the intervention.

Limitations

This work is not without limitations. Firstly, these results are contextualized for a sample of Argentine children at social risk, so they cannot be generalized to children from other regions and sociocultural contexts. Secondly, the school-based intervention was carried out a short period of time, with a small sample of schoolchildren. Thirstily, groups were not randomized and the long-term effects of the intervention were not measured. Fourthly, the intervention was limited to strengthening cognitive resources; it would be desirable for future studies to incorporate activities aimed at promoting socio-emotional aspects in order to strengthen other aspects of child development. Finally, this study did not analyze the transfer of cognitive gains to aspects of children's daily life.

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