Revista de Psicodidáctica 26 (2021) 20–27

Revista de Psicodidáctica

www.elsevier.es/psicod

Original

Effect of the EFE-P program on the improvement of executive functions in Early Childhood Education☆

Miriam Romero-López*, M. Carmen Pichardo, Ana Justicia-Arráez, and Francisco Cano-García

Department of Evolutionary Psychology and Education, University of Granada, Spain

ARTICLE INFO

Article history:
Received 19 April 2020
Accepted 26 August 2020
Available online 25 October 2020

Keywords:
Executive development
Inhibitory control
Working memory
Cognitive flexibility
Early Years Education
Intervention

ABSTRACT

Intervention to improve executive functions is crucial in preschool education because preschoolers benefit most from intervention programs. The objective of this study is to present the results obtained from implementing the Ëxecutive Function Training Program in Preschool(̈EFE-P), which is claimed to improve inhibitory control, working memory and cognitive flexibility. The participants in this study are 100 children aged five to six years, drawn from two schools in Granada (Spain). In order to assess the impact of the program, pre- and post-intervention measurements are obtained from members of the experimental group, and these compared with corresponding measurements for a control group, using hierarchical regression and linear mixed model analysis. Executive functions are evaluated using the Behavior Rating Inventory of Executive Function–Preschool Version (BRIEF-P). The study results show that the intervention program has a significant impact on all the executive function variables analyzed, with large effect sizes (Cohen's f and Hedges' g). Executive functions are essential for many of the skills required in adult life, such as memory, creativity, flexibility, self-control and compliance with rules and norms. For this reason, there is a real need to create programs that promote the development of these functions in the early stages of life. Programs such as EFE-P can be implemented by teachers within the standard curriculum, using materials that are readily available in schools.

Efecto del programa EFE-P en la mejora de las funciones ejecutivas en Educación Infantil

Palabras clave:
Desarrollo ejecutivo
Control inhibitorio
Memoria de trabajo
Flexibilidad cognitiva
Educación infantil
Intervención

RESUMEN

La intervención para la mejora de las funciones ejecutivas es crucial en educación preescolar puesto que el alumnado de esta etapa obtiene mayores beneficios de los programas de intervención. El objetivo de este estudio es presentar los resultados obtenidos de la aplicación del "Programa de entrenamiento en funciones ejecutivas en educación infantil" (EFE-P), con el que se pretende la mejora del control inhibitorio, la memoria de trabajo y la flexibilidad cognitiva. Los participantes en este estudio son 100 niños y niñas de cinco y seis años, procedentes de dos colegios de Granada (España). Para evaluar el impacto del programa, se obtienen mediciones previas y posteriores a la intervención de los miembros del grupo experimental, y se comparan con las mediciones correspondientes a un grupo de control, utilizando la regresión jerárquica y el análisis mediante un modelo lineal mixto. Las funciones ejecutivas se evalúan mediante la Evaluación Conductual de la Función Ejecutiva - Versión Infantil (BRIEF-P). Los resultados del estudio muestran que el programa de intervención tiene un impacto significativo en todas las variables de función ejecutiva analizadas, con grandes tamaños de efecto (f de Cohen y g de Hedges). Las funciones ejecutivas son esenciales para muchas de las aptitudes necesarias en la vida adulta, como la memoria, la creatividad, la flexibilidad, el autocontrol y el cumplimiento de las reglas y normas. Por esta

PII of original article:S1136-1034(20)30036-8.

☆ Please cite this article as: Romero-López M, Carmen Pichardo M, Justicia-Arráez A, Cano-García F. Efecto del programa EFE-P en la mejora de las funciones ejecutivas en Educación Infantil. Revista de Psicodidáctica. 2021;26:20–27.

* Corresponding author.
E-mail address: miriam@ugr.es (M. Romero-López).

razón, existe una necesidad real de crear programas que promuevan el desarrollo de estas funciones en las primeras etapas de la vida. Los programas validados como el EFE-P pueden ser llevados a cabo por el profesorado dentro del plan de estudios estándar, utilizando materiales que están fácilmente disponibles en las escuelas.

Introduction

Executive functions refer to the skills that allow people to have goals and carry them out by ignoring the emotions, behaviors or thoughts that may interfere with their achievement. These cognitive functions are divided into specific skill interrelationships, including inhibitory control, working memory and cognitive flexibility (Santa-Cruz & Rosas, 2017). Inhibitory control is the ability to deliberately control thoughts, feelings and behavior, inhibiting or diminishing the appeal of inappropriate conduct (Diamond, 2013; Santa-Cruz & Rosas, 2017).

Another crucial component of executive functions is working memory, i.e. the capacity to hold a task or idea in mind while at the same time adding relevant information or removing irrelevant information, in order to achieve a goal (Miyake et al., 2000). Working memory is fundamental to reasoning and problem solving, both of which require information retention and the analysis of interconnections among data items (Diamond & Ling, 2016).

The third element, cognitive flexibility, refers to the individual's capacity to adapt in accordance with environmental constraints, as well as the ability to adopt different perspectives and to view questions from different perspectives (Diamond, 2013; Santa-Cruz & Rosas, 2017). When a difficult problem is encountered, cognitive flexibility makes it possible to view it in different ways, thereby facilitating the search for a solution.

There are different programs designed for the improvement of executive functions in the early education stage (Blair & Raver, 2014; Fernández-Abella, 2018; Holmes & Gathercole, 2014; Thorell et al., 2009; Traverso et al., 2015; Walk et al., 2018). Among them, there are mainly two programs included in the preschool curriculum. The first is the Tools of the Mind: The Vygotskian Approach to Early Childhood Education (Bodrova & Leong, 2019) the purpose of which is the improvement of executive functions through activities involving speech regulation, make-believe play, and memory and attention games. Studies testing the efficacy of this program have shown that among the children who participated, not only were executive functions improved but these improvements were generalized to other areas, such as social behavior and academic achievement (Bodrova & Leong, 2019; Diamond et al., 2019).

The second program is the Chicago School Readiness Project (CSRP; Raver et al., 2011), an intervention based on emotional and behavioral development that was designed to bolster the educational preparation of low-income preschool children. Raver et al. (2011) reported that self-regulation, attention, impulse control and executive functions were all improved among those who participated in the program.

There are also short-term interventions where the work is more intensive with two to eight sessions per week. This is the case, for example, of Cogmed Working Memory Training, the program designed by Traverso et al. (2015) and the program designed by Rothlisberger et al., 2012. Short-term programs have been shown to be effective in improving cognitive flexibility (Röthlisberger et al., 2012; Traverso et al., 2015; Traverso et al., 2019) and working memory (Röthlisberger et al., 2012; Thorell et al., 2009; Traverso et al., 2015). However, the results in improving inhibitory control are not conclusive. Three studies, conducted with children presenting normal levels of development, observed no increase in inhibitory control (Rueda et al., 2005; Rueda et al., 2012; Thorell et al., 2009), one recorded significant effects only in preschool children with previously poor inhibitory abilities (Dowsett & Livesey, 2000) and Röthlisberger et al. (2012) found a significant improvement in inhibitory control after implementation of their program.

Comparing the effects produced by different executive function programs designed for early childhood education is difficult due to the variability of these programs in terms of duration, focus (individuals, small group or large group) and materials used (tokens, computers, role play, etc.) (Traverso et al., 2015). Nevertheless, the results of studies of early interventions focused on enhancing executive functions are generally promising, and suggest that various strategies may be useful for this purpose, in the case of preschool children.

Despite the growing interest in promoting executive functions in children, in Spain there are no known executive training programs that are included in the curriculum of this educational stage. In Spain, the first stage in the education system is that corresponding to early childhood, when the main objective is to contribute to children's physical, emotional, social and intellectual development. Kindergartens and preschool centers are mostly public and free of charge. Attendance is not compulsory but is nevertheless almost universal: almost 100% of children attend such a center before starting primary school at the age of six years (Ministerio de Educación y Formación Profesional, 2020). In this context, application of the "Executive Function Training Program in Preschool" (EFE-P), with play-based activities and appropriate to the needs and abilities of preschool children, would contribute to achieving the goals set for this stage of the education system, and could be provided within the ordinary timetable.

The EFE-P program is the first executive training program designed to be applied within the preschool curriculum and would be the first program with these characteristics validated in the Spanish context. On the other hand, unlike other programs used in the educational context, which are mainly focused on the cognitive part of the executive functions (for example, Röthlisberger et al., 2012), the EFE-P program includes the most emotional and behavioral aspects of these functions. For this reason, in addition to improving students' executive functions, it could also have positive effects in the emotional and behavioral realm. The program focuses on playful activities and includes physical, auditory and verbal activities. In addition, the EFE-P program provides contextualized, realistic learning environments, a variety of student-centered methodologies, such as case studies, problem-based approach and discovery learning, among others, that can be considered essential methodological strategies to promote critical thinking, active participation and reflection. Real-world focused programs, such as game-based executive coaching programs included in the preschool curriculum, have greater benefits than computer-based training or programs that focus solely on cognitive training (Diamond & Ling, 2016).

In addition, providing teachers with programs that can be easily used as methodological resources can have positive effects on improving students' cognitive functioning. This benefit will be especially important in preschool settings, because younger children benefit more from intervention programs than older children, as some studies have shown (Santa-Cruz & Rosas, 2017).

In view of these considerations, the objective of the study described in this paper is to analyze the effectiveness of the EFE-P program in improving the executive functions of children in the final year of preschool education. Taking into account the find-

Table 1
Distribution of participants by school, group and gender

		Male		Female	
		n	%	*n*	%
School 1	Control group	12	48	13	52
	Experimental group	12	48	13	52
School 2	Control group	11	44	14	46
	Experimental group	11	44	14	56

ings of the theoretical review presented, the children taking part in the EFE-P program are expected to achieve significantly improved executive functions, in comparison with their non-participating peers.

Method

Participants

The participants in the study were 110 children aged 5 to 6 years (M_{age} = 5.48 years, SD_{age} = 0.23), drawn from two nursery schools in Granada, Spain. All the children were European Caucasians living in Granada. In this country, children aged three to five years attend nursery school or preschool from September to June, with breaks at Christmas and Easter as well as in the summer. The two school populations had similar socio-economic and cultural characteristics (average net household income around €26,000, close to the national average), according to information received from the school management teams. Initially, ten children were excluded from the study because they were receiving support for special educational needs, not participating in the group assignment. In these schools, and many others in Spain, children with special educational needs (such as those with Down's syndrome or Asperger's) are completely integrated into the mainstream classroom. However, for the present study it was considered necessary to first establish the effect of the EFE-P program on children with typical developmental levels. In consequence, the final study sample was composed of 100 participants.

Considering the relatively small sample size, the trial was randomized individually, rather than by clusters, which usually requires a larger sample. To address the potential lack of independence among observations (obtained at only two sites), the participants were assigned via a three-phase process. In phase 1, the participants were numbered, from 1 to 100); in phase 2, fifty participants were randomly selected from each school; and in phase 3, in each school, half of these fifty were randomly assigned to the treatment (n = 25) and the other half to the control group (n = 25) (i.e., n = 50 to treatment and n = 50 to control, in total). The distribution of participants by schools is shown in Table 1.

The control groups were composed of 50 children, 23 male and 27 females (M_{age} = 5.50 years, SD_{age} = 0.26), as were the experimental groups, 23 male and 27 females (M_{age} = 5.46 years, SD_{age} = 0.20).

Instruments

The *Behavior Rating Inventory of Executive Function–Preschool Version* (BRIEF-P) was used to evaluate executive functions (Bausela-Herreras & Luque-Cuenca, 2017; Gioia et al., 2002). The instrument adjustment rates in the study population were χ^2 = 3840.040, df = 1880, CFI = .904, TLI = .890, RMSEA = .052. This scale contains 63 items, grouped into five subscales: (1) *Deficits in inhibition* (16 items, α = .96, CR = .97, ω = .97, and AVE = .70); (2) *Deficits in flexibility* (10 items, α = .73, CR = .91, ω = .93, and AVE = .61); (3) *Deficits in emotional control* (10 items, α = .89, CR = .91, ω = .88, and AVE = .45); (4) *Deficits in working memory* (17 items, α = .94, CR = .96, ω = .96, and AVE = .63); (5) *Deficits in planning and organization* (10 items, α = .84, CR = .93, ω = .94, and AVE = .61). Although scores on these subscales are sometimes summed to form a global measure of executive function, whether they can be viewed as separable or rather as a single domain is debatable (Miyake et al., 2000). The BRIEF-P items were scored on a Likert scale ranging from 0 (never) to 2 (frequently).

Procedure

The study protocols were previously approved by the University of Granada's Human Research Bioethics Committee, which overviewed the project and ensured that it met the requirements of the Code of Ethics in Psychology and complied with Spanish legislation on data protection. Once the project was approved, all the nursery schools in the capital of Granada (Spain) were consulted to find out about their interest in participating in the research. Finally, 13 schools showed interest in participating. Among all the schools that confirmed their interest, a random selection was made, and two schools were selected. Permission to conduct this study was obtained from the two schools, from the teachers concerned and from the parents. Before starting, the study objectives were explained to the teachers involved. In addition, a meeting was held at each school to inform the parents about the study, its objectives and the procedures involved. Parents who did not attend the meeting were sent a letter with this information. There were no refusals; all parents gave their signed consent for their children to take part in the study.

For the purposes of this study, an evaluator was instructed by members of the research team on the types of behavior to be observed and evaluated, as well as the evaluation times and situations. The evaluator had a degree in early childhood education. Likewise, to check the evaluator's observation skills, a pilot test was carried out in a centre not involved in the research, triangulating the evaluator's record and the centre's teacher's record. Similarly, for two months and also by the research team, an infant education teacher from outside the schools was trained to apply the EFE-P program in the experimental group and was instructed on the activities (objective, procedure and expected results) to be carried out with the control group. Neither the evaluator nor the early childhood education teacher was aware of the research objectives, and were specifically hired for the present investigation.

The children's behavior in the classroom and in the playground was observed from October to December by the evaluator, who was present for four-hour sessions, held at similar times and on similar days for all participants, thus ensuring that all members of the control and experimental groups were observed at comparable times and places. Following this observation, the evaluator filled out the BRIEF-P (pre-intervention phase) executive-function questionnaire for each participating child. Then, for two and a half months, the contracted early childhood teacher carried out the intervention phase. To this end, it applied the EFE-P program in the experimental group and carried out various activities related to the preschool curriculum in the control group. These activities included stories, drawing, Lego-building and group games. As in the evaluation, intervention days and times were rotated so that the experimental and control groups had similar schedules. The schools provided a classroom to carry out the activities for the control and experimental groups. On the established days and times, the teacher trained in the EFE-P program would transfer the corresponding group (experimental or control) to that classroom to carry out the programmed activities. The rest of the students continued in their regular classes with their teachers.

The EFE-P program is designed to be used in the classroom with children aged five to six years, to enhance the development of executive functions by improving inhibitory control, working memory and cognitive flexibility. The program was implemented

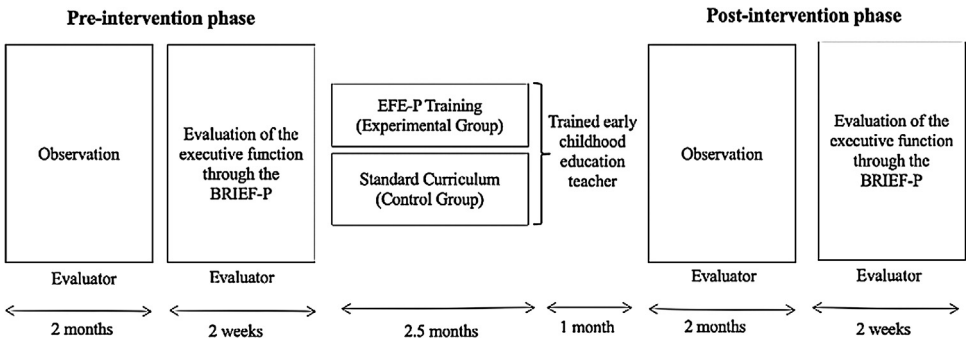

Figure 1. Time distribution of study activities.

for the first time as part of the present investigation. The program is divided into three thematic units (inhibitory control, working memory and cognitive flexibility) in which the level of difficulty is progressively increased. Each unit is comprised of seven sessions of approximately 30 minutes. The full program, thus, consists of 21 sessions, held twice weekly. In the sessions observed, a game-based approach was adopted in order to motivate the children. Some began with a group activity in which the children were told a story about two friends, Carla and Pepe, who sometimes didn't think carefully before acting. In one story, for example, Pepe takes a ball off Carla and she hits him. The program leader discussed with the children whether they think Carla reacted correctly and what they would do in such a situation. In addition, they are taught different impulse control techniques, such as the turtle technique or the traffic light technique. Other sessions began with stories well known to these children, but in which the characters' roles were changed in order to encourage cognitive flexibility. For example, the contract teacher told a modified version of the story of Little Red Riding Hood, in which the wolf was good, and the little girl was bad. Other activities were varied, including motor, hearing and listening activities, and took the form of games, paper and pencil tasks or stories. For example, one activity was the night-day task, in which the children were instructed to say "night" when they were shown a drawing of a day-time scene and to say "day" when they were shown a nocturnal one. The activities proposed are all playful and dynamic and different types of groupings are used (individual, pair and whole-group work) depending on the nature of the activity. The essential principle of the EFE-P program is to learn while having fun. The aim is not only to develop the cognitive aspects of executive functions (also known as 'cool executive functions') but also to address more behavioral and emotional aspects (or 'hot executive functions').

One month after the end of the intervention, the same evaluator initiated a new period of two months' observation (post-intervention phase). After this, the children were evaluated with the BRIEF-P executive-function questionnaire (post-intervention phase). Figure 1 shows the sequence of activities undertaken in this research program, the tasks performed and the personnel responsible.

When the completed questionnaire was received, the data were analyzed and the research report written. Finally, the schools were informed of the results obtained.

Design and data analysis

On the basis of the research objectives and hypotheses described above, this experimental study was designed as an individually randomized trial with two groups (experimental and control) and two phases of assessment (pre-intervention/baseline and post-intervention). The initial analyses included: (1) descriptive statistics (means and standard deviations), obtained separately for the control and experimental groups, according to the scores awarded for the evaluation subscales at the two assessment periods (pre-intervention/baseline and post-intervention); and (2) a preliminary comparative description of these scores by means of a multivariate analysis.

In addition, four alternative models of the underlying structure of the BRIEF-P scores were compared through confirmatory factor analysis (CFA) using Mplus, version 6.11: unidimensional, second-order, bifactor and first-order (five correlated factors). The following indexes were used to check the fit of the models: Compartive Fit Index (CFI); Tucker Lewis Index (TLI); and Root Mean Square Error of Approximation (RMSEA).The first three models, which included a general factor, yielded either low goodness-of-fit indices, $\chi^2 = 5195.623$, $df = 1890$, CFI = .687, TLI = .676, RMSEA = .094 (unidimensional) or didn't converged (second-order and bifactor). By contrast, the latest model showed somewhat better goodness-of-fit indices ($\chi^2 = 3840.040$, $df = 1880$, CFI = .904, TLI = .890, RMSEA = .052). These results suggested that the first-order (five correlated factors) appeared to be best representation of the latent structure of the BRIEF-P responses and, therefore, that the use of a global measure (i.e., general factor) for this test should be dismissed.

Reliability was investigated by using Cronbach's alpha (α), composite reliability (CR), McDonald's omega (ω), and average variance extracted (AVE) (cut-off values .70 for the first three, and .50 for the last) (Diamantopoulos & Siguaw, 2000; Dunn et al., 2014; Fornell & Larcker, 1981).

The central analyses included separate hierarchical regression analyses, performed for two purposes: (1) to determine the effects of the EFE-P intervention on each outcome variable (i.e., the children's performance in the BRIEF-P); (2) to estimate the effect size of the intervention (e.g., Cohen's f^2). Hierarchical regression was employed to capture the effect of the intervention (experimental vs. control) taking into account the possible influence of school membership and the baseline measures (step 1). The initial and central analyses were both carried out using the Statistical Package for the Social Sciences (SPSS), version 20.0.

In addition to these analyses, for variables in which the effect of the school of origin was significant, linear mixed models (LMM) (Bell et al., 2019) were used, defining school membership as a random effect and the intervention as a fixed factor. These models combine fixed and random effects, that is, they incorporate different types of effects or influences of the explanatory variables on the response, with respect to various parameters addressed. Moreover, they allow us to model the variance (instead of assuming that it is constant) and the presence of correlated observations.

The "lme" function of the "nlme" package (Pinheiro et al., 2013) in the R statistical software was used to create the LMM, which were implemented with random intercept, that is, the two schools were considered as a random factor. The models fulfilled the assumptions of multivariate normality, homoscedasticity of the

variance-covariance, linearity and non-existence of multicollinearity, presenting a variance inflation factor of less than 10 (Kutner et al., 2005). Interpretation of the regression analyses was simplified by using the effect size measure f^2 proposed by Cohen (Cohen, 1988). Cohen's guidelines (Cohen, 1988) for the interpretation of the f-squared statistic (f^2) as a measure of the linear regression effect size, suggested it should be considered 'small', 'medium' or 'large' when f^2 was .02, .15, or .35, respectively. Moreover, Hedges' g effect size was computed, according to the author's recommendations (Hedges, 2007), since our study was designed as an individually randomized trial. The "esc_beta" function of the R software package was used for this purpose (Lüdecke, 2018).

Results

Table 2 presents the descriptive statistics for each measure obtained for the control and experimental groups in the pre-intervention and post-intervention phases.

A preliminary comparative description, by means of a multivariate analysis, of the scores obtained by control and experimental groups in the post-intervention phase revealed, as expected, statistically significant differences, Wilk's Lambda = .45, $F(5,94) = 17.17$, $p < .001$. Unexpectedly, both groups also differed significantly in the scores obtained in the obtained in the pre-intervention phase, Wilk's Lambda = .66, $F(5,94) = 9,66$, $p < .001$, which confirmed the need for controlling these differences in subsequent analyses.

The effects of the EFE-P program on each of the executive function variables were assessed using a series of hierarchical regression analyses. Step 1 includes school membership (coded as a dummy variable: 0 = School 1, 1 = School 2), and the pre-intervention variables (coded as continuous variables). Step 2 incorporates the intervention performed (coded as a dummy variable: 0 = Control group; 1 = Experimental group). The results of these analyses are presented in Table 3. For the sake of clarity, the results corresponding to each step 1 are omitted. Nevertheless, the R^2 corresponding to Step 1 are included to facilitate comparison with those recorded in Step 2.

In general, the effect of the intervention program on all the executive function variables was statistically significant, after controlling for the school and the pre-intervention variables: *inhibition* ($t = -10.27$, $p < .001$), *flexibility* ($t = -7.70$, $p < .001$), *emotional control* ($t = -8.38$, $p < .001$), *working memory* ($t = -12.11$, $p < .001$), and *planning and organization* ($t = -7.57$, $p < .001$). Moreover, the percentage of variance accounted for by the intervention, and the corresponding effect size were large for all variables analyzed. The effect of the intervention program was also statistically significant and the effect size was large for all variables of the executive functions evaluated.

Table 3 also shows that the school variable is statistically significant for two variables: *inhibition* ($t = 2.68$, $p < .009$) and *emotional control* ($t = 3.83$, $p < .001$). For this reason, in addition to the above-mentioned regression analyses, two linear mixed model (LMM) analyses, carried out using the lme function of the nlme in the R (Pinheiro et al., 2013), were performed (using the restricted maximum likelihood criterion) for each of these two variables.

These LMM analyses, in which the intervention was treated as a fixed factor (i.e., experimental or control group) and the school as a random effect (i.e., assuming random intercepts for each school), were used to take into account the possible lack of independence among observations due to the influence of school membership. The results of these analyses are shown in Table 4.

Table 4 shows that, with respect to the LMM analyses of the two dependent variables indicated, there were no significant differences between the schools, since the inter-school variance was smaller than the residual variance, as can be seen in the random effects section. On the other hand, there were significant differences between the intervention and the control groups, after allowing for possible effects of the school. Thus, the following values were found: *inhibition* ($t = -9.82$, $p < .001$), *emotional and control* ($t = -7.82$, $p < .001$), as can be seen in the fixed effects section. The participants in the experimental group revealed significantly lower scores for *inhibition* and *emotional control* than those in the control group.

Discussion

This study was designed to determine the impact of the EFE-P program, for preschool children aged five to six years, focusing on inhibitory control, working memory and cognitive flexibility; the reasons being that: (1) very few programs of this type are currently offered in Spain; and (2) it seems logical to provide training programs for preschool children that are specifically designed to enhance and develop executive functions, which are known to be crucial to academic and social success (Diamond et al., 2019; Li et al., 2020; Traverso et al., 2019). Generally consistent with our prediction, our findings supported the effectiveness of the EFE-P program.

To increase the number of participants and, therefore, the validity of the program, two control groups and two experimental groups were analyzed. These groups did not start from similar scores in the pre-intervention phase, and so this variable had to be controlled. Similarly, it was necessary to establish that the effects of the intervention were similar in both schools.

After controlling the pre-intervention scores and the school variable, the data continued to support the internal validity of the program. We conclude, therefore, that the children who took part in the EFE-P program reduced their deficits in executive functions to a greater extent than their peers who received only the standard curricular activities. Thus, in the post-intervention phase the program participants recorded lower scores for deficits in inhibition, flexibility, emotional control, working memory and planning-organization.

The control group, despite not participating in the program, also achieved higher scores for executive functions, although the improvement was less than that obtained by the experimental group. This outcome for the control group, though not due to a specific intervention, could be explained by the effect of education itself or by the normal cerebral development of children of this age. This post-intervention improvement among children not taking part in the intervention program has also been found in other studies, such as the one conducted by Blair and Raver (2014), using the Tools of the Mind program. Corroborating our findings, other programs have also been shown to be effective in improving executive functions in pre-school children. For example, Raver et al. (2011) found that students who participated in the Chicago School Readiness Project program scored higher in executive functions than their control group peers. Similarly, studies have shown that students who participated in the Cogmed Working Memory Training program had higher working memory scores than students in the control group (e.g., Holmes & Gathercole, 2014; Thorell et al., 2009). In this line, Traverso et al. (2015) designed an executive intervention program and found that children who participated in their program obtained better post-intervention scores in inhibitory control, cognitive flexibility and working memory than comparable non-participant children.

However, not all studies analyzing the outcomes achieved by programs aimed at enhancing the components of executive functions have obtained significant results for all the variables considered. For example, Röthlisberger et al. (2012) implemented a training program in inhibitory control, working memory and cog-

Table 2
Mean scores and standard deviations for the study variables, by groups and phases

	Pre-intervention				Post-intervention			
	School 1		School 2		School 1		School 2	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Control								
Inhibition	0.59	0.52	0.30	0.32	0.50	0.45	0.25	0.28
Flexibility	0.22	0.22	0.32	0.32	0.16	0.16	0.26	0.24
Emotional Control	0.47	0.25	0.35	0.30	0.40	0.22	0.26	0.28
Working Memory	0.47	0.32	0.45	0.41	0.37	0.24	0.40	0.35
Planning and Organization	0.56	0.30	0.50	0.34	0.40	0.26	0.40	0.31
Experimental								
Inhibition	0.42	0.41	0.37	0.36	0.08	0.13	0.07	0.10
Flexibility	0.30	0.33	0.19	0.23	0.06	0.12	0.06	0.09
Emotional Control	0.40	0.37	0.31	0.33	0.08	0.15	0.08	0.14
Working Memory	0.52	0.31	0.40	0.28	0.10	0.10	0.07	0.11
Planning and Organization	0.39	0.22	0.30	0.24	0.08	0.09	0.08	0.12

Note. *Inhibition:* deficits in inhibition, *Flexibility:* deficits in flexibility, *Emotional Control:* deficits in emotional control, *Working Memory:* deficits in working memory, *Planning and Organization:* deficits in planning and organization.

Table 3
Summary of hierarchical regression analyses predicting post-intervention test scores (i.e., each executive function measure), after controlling for baseline scores and school

Predictor	R^2	ΔR^2	β	*t*	*Cohen* f^2	*Hedge's g*
Inhibition						
School	.640[a]		.12	2.68**		
Pre_Inhibition			.79	18.31***		
Intervention	.828[b]	.188	−.43	−10.27***	1.09 [.44, 2.79]	−0.94 [−0.53, −1.36]
Flexibility						
School	.636[a]		.02	0.46		
Pre_Flexibility			.78	16.10***		
Intervention	.775[b]	.139	−.37	−7.70***	0.62 [.16, 1.62]	−0.78 [−0.38, −1.19]
Emotional Control						
School	.481[a]		.22	3.83***		
Pre_Emotional Control			.62	11.71***		
Intervention	.700[b]	.219	−.47	−8.38***	0.73 [.23, 1.89]	−1.04 [−0.63, −1.46]
Working Memory						
School	.463[a]		.02	0.49		
Pre_Working Memory			.69	14.47***		
Intervention	.788[b]	.325	−.57	−12.11***	1.53 [.70, 3.89]	−1.36 [−0.93, −1.79]
Planning and Organization						
School	.640[a]		.01	0.08		
Pre_Planning and Organization			.68	13.11***		
Intervention	.774[b]	.134	−.39	−7.57***	.059 [.15, 1.56]	−0.82 [−0.42, −1.23]

Note. R^2: Squared multiple correlation, [a]: R^2 in step 1, [b]: R^2 in step 2, ΔR^2: Change in R^2, β: Standardized regression coefficient; *t*: t statistic for adjusted means (i.e., after controlling for the other predictors in the equation), *Cohen's* f^2: Cohen's f square effect size for regression (calculated from the R^2) (Cohen, 1988), *Hedge's g*: Hedge's g unbiased effect-size (calculated by converting t-values into g measure) (Del Re, 2013), 95% lower and upper confidence intervals for both effect sizes are shown in square brackets. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 4
Linear mixed model results for intervention effects on the variables inhibition and emotional control

	DV: Post *inhibition*			DV: Post *emotional control*		
	Estimate	*SE*	*t*	Estimate	*SE*	*t*
Fixed effects						
Intercept	.11	.03	4.26**	.14	.03	4.81**
Pre-intervention	.60	.03	17.27**	.49	.05	10.35**
Intervention	−.03	.03	−9.82**	−.23	.03	−7.82**
Random effects						
Intercept	.01			.01		
Residual	.14			.15		

Note. DV: Dependent variable, *SE*: Standard error. The Hedges' g effect size was −0.95 (−0.53, −1.36) for Post *inhibition*, −1.04 (−0.62, −1.46) for Post *emotional control*.

nitive flexibility, aimed at children aged five to six years. These authors found significant effects only in inhibitory control in the six-year-olds and substantial training effects in cognitive flexibility and working memory in the five-year-olds. This discrepancy may be due to the difference in the tasks used. The study carried out by these authors uses purely cognitive tasks where no emotional or behavioral component of the executive functions is involved. Similarly, the intervention developed by Walk et al. (2018) despite improving some executive components, such as inhibitory control and working memory, presented small effect sizes. In contrast, and despite certain reservations due to the size and characteristics of the sample, the results of the present investigation show that the EFE-P program not only appears to be a valid instrument for enhancing executive functions, it also presents large effect sizes.

On the other hand, the discrepancies found with these studies may also be due to the form of evaluation used. It should be noted that the evaluation of executive functions, due to their complexity, the absence of a clear, operational and consensual definition,

has been a challenge in recent years, especially when dealing with preschool children. In this study an ecological measure has been used for the assessment of executive functions, something that seems important at an early age since many of the neuropsychological tests used often introduce response mechanisms with which young children are unfamiliar, such as using the computer keyboard or mouse to respond. However, it should be noted that there are several factors that can significantly affect the assessment of preschool children, including the following: they have very limited attention span, tire quickly, may make mistakes on tasks that are unattractive, have more immature communication skills and less awareness of the requirements of the assessment situation (Howard & Melhuish, 2017).

Furthermore, some programs, such as Cogmed Working Memory Training, focus on training a specific component of executive functions or require expensive materials that are not available to all schools, such as advanced computing equipment (Traverso et al., 2015). Another advantage of EFE-P is that it does not address any particular executive component, but instead seeks to enhance all the major functions.

Another important consideration is that many programs aimed at improving educational capacities are intended for a very specific population, for example, premature children (García-Bermúdez et al., 2019), or those with autism spectrum disorder (Acero-Ferrero et al., 2017), attention deficit hyperactivity disorder (Bikic et al., 2018) or serious mental illness (Best et al., 2019).

Whilst acknowledging the importance of working with such populations, it is also necessary to design and evaluate programs for those with typical levels of development. From a practical standpoint, it is important to provide schools with programs that facilitate their work, and that these programs should be rigorously evaluated within the context in which they will be put into practice. The development of interventions aimed at enhancing executive functions, implemented as part of the standard curriculum, could help reduce the present lag in executive development between typical and at-risk children, especially when they are not diagnosed. This is one of the outstanding aspects of the EFE-P program, which is designed to be readily applied by teachers, as part of everyday activities within the curriculum. The program includes a detailed description of the activities to be carried out and does not require material other than that normally present in a preschool classroom. Nor does it call for expensive training for the teachers. Thus, the EFE-P program can readily be implemented in any school, including those catering for at-risk children.

In conclusion, the EFE-P program aims to improve executive functions in the children's stage. The results add to evidence that training preschool teachers in the development of these skills can lead to significant gains in the executive functions of children at this stage (Blair & Raver, 2014; Diamond et al., 2019; Traverso et al., 2015; Walk et al., 2018). In addition, by including activities based on real-life situations, such as problem solving, where preschool children have difficulty controlling and guiding their behavior, participation in the program could facilitate the generalization or transfer of executive improvements to other tasks or similar situations. Similarly, the EFE-P program can be implemented without the need for a large number of resources, using materials that are within any average early childhood classroom, which could promote its application in more disadvantaged contexts.

Limitations and future research

Some of the limitations of the study are inherent to the evaluation instrument employed. In order to evaluate executive functions, inventory was completed by a properly trained evaluator. However, to fully validate our findings, it would have been interesting to use a hetero-evaluative method, including other informants, such as parents or peers. Such an approach would have provided information about children's behavior in contexts other than the school environment, and would have provided a broader idea of the impact achieved by the program.

In addition to the above, it is difficult to extrapolate the present results to other contexts, as the study participants were drawn from just two schools in the province of Granada (Spain), and were all from the same academic year. Therefore, the study has little external validity.

In view of these limitations, future research is needed in the form of longitudinal studies to test whether the effects of the program are maintained over time. Moreover, the different individual and contextual factors that may affect executive functions should be taken into account. Similarly, it would be interesting to analyze whether children who have problems in executive functions benefit more from the program than their unproblematic peers. Finally, a sample that is more representative of the population, i.e. which considers different stages of child development, should be selected for analysis.

Funding

This research work has not received any specific financial support from public, private or non-profit institutions.

Conflict of interests

None.

References

Acero-Ferrero, M., Escolano-Pérez, E., & Bravo-Álvarez, M. Á. (2017). Transferring learning to everyday life in autism spectrum disorder through an executive functions training programme. *Estudios de Psicología*, *38*(2), 523–536. http://dx.doi.org/10.1080/02109395.2017.1295574

Bausela-Herreras, E., & Luque-Cuenca, T. (2017). Evaluación conductual de la función ejecutiva-versión infantil (BRIEF-P, versión española): Fiabilidad y validez. *Acta de Investigación Psicológica*, *7*(3), 2811–2822. http://dx.doi.org/10.1016/j.aipprr.2017.11.002

Bell, A., Fairbrother, M., & Jones, K. (2019). Fixed and random effects models: Making an informed choice. *Quality & Quantity*, *53*(2), 1051–1074.

Best, M. W., Gale, D., Tran, T., Haque, M. K., & Bowie, C. R. (2019). Brief executive function training for individuals with severe mental illness: Effects on EEG synchronization and executive functioning. *Schizophrenia Research*, *203*, 32–40. http://dx.doi.org/10.1016/j.schres.2017.08.052

Bikic, A., Leckman, J. F., Christensen, T. Ø., Bilenberg, N., & Dalsgaard, S. (2018). Attention and executive functions computer training for attention-deficit/hyperactivity disorder (ADHD): Results from a randomized, controlled trial. *European Child & Adolescent Psychiatry*, *27*(12), 1563–1574. http://dx.doi.org/10.1007/s00787-018-1151-y

Blair, C., & Raver, C. C. (2014). Closing the achievement gap through modification of neurocognitive and neuroendocrine function: Results from a cluster randomized controlled trial of an innovative approach to the education of children in kindergarten. *Plos One*, *9*(11), 1–13. http://dx.doi.org/10.1371/journal.pone.0112393

Bodrova, E., & Leong, D. J. (2019). Tools of the mind: The vygotskian-based early childhood program. *Journal of Cognitive Education and Psychology*, *17*(3), 223–237. http://dx.doi.org/10.1891/1945-8959.17.3.223

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed). New York University.

Del Re, A. C. https://cran.r-project.org/web/packages/compute.es/compute.es.pdf, 2013

Diamantopoulos, A., & Siguaw, J. A. (2000). *Introducing LISREL: A guide for the uninitiated*. Sage.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168. http://dx.doi.org/10.1146/annurev-psych-113011-143750

Diamond, A., & Ling, D. S. (2016). Conclusions about interventions, programs, and approaches for improving executive functions that appear justified and those that, despite much hype, do not. *Developmental Cognitive Neuroscience*, *18*, 34–48. http://dx.doi.org/10.1016/j.dcn.2015.11.005

Diamond, A., Lee, C., Senften, P., Lam, A., & Abbott, D. (2019). Randomized control trial of Tools of the Mind: Marked benefits to kindergarten children and their teachers. *Plos One*, *14*(9), 1–27. http://dx.doi.org/10.1371/journal.pone.0222447

Dowsett, S. M., & Livesey, D. J. (2000). The development of inhibitory control in preschool children: Effects of "executive skills" training. *Developmental Psychobiology*, *36*(2), 161–174. http://dx.doi.org/10.1002/(sici)1098-2302(200003)36:2<161::aid-dev7>3.0.co;2-0

Dunn, T. J., Baguley, T., & Brunsden, V. (2014). From alpha to omega: A practical solution to the pervasive problem of internal consistency estimation. *British Journal of Psychology*, *105*(3), 399–412. http://dx.doi.org/10.1111/bjop.12046

Fernández-Abella, R., Peralbo-Uzquiano, M., Durán-Bouza, M., Brenlla-Blanco, J. C., & García-Fernández, M. (2018). Programa de intervención virtual para mejorar la memoria de trabajo y las habilidades matemáticas básicas en Educación Infantil. *Revista de Psicodidáctica*, *24*(1), 17–23. http://dx.doi.org/10.1016/j.psicod.2018.09.002

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*, 39–50. http://dx.doi.org/10.2307/3151312

García-Bermúdez, O., Cruz-Quintana, F., Pérez-García, M., Hidalgo-Ruzzante, N., Fernández-Alcántara, M., & Pérez-Marfil, M. N. (2019). Improvement of executive functions after the application of a neuropsychological intervention program (PEFEN) in pre-term children. *Children and Youth Services Review*, *98*, 328–336. http://dx.doi.org/10.1016/j.childyouth.2018.10.035

Gioia, G. A., Espy, K. A., & Isquith, P. K. (2002). *Behavior rating inventory of executive function, preschool version (BRIEF-P)*. Psychological Assessment Resources.

Hedges, L. V. (2007). Effect sizes in cluster-randomized designs. *Journal of Educational and Behavioral Statistics*, *32*(4), 341–370. http://dx.doi.org/10.3102/1076998606298043

Holmes, J., & Gathercole, S. E. (2014). Taking working memory training from the laboratory into schools. *Educational Psychology*, *34*(4), 440–450. http://dx.doi.org/10.1080/01443410.2013.797338

Howard, S. J., & Melhuish, E. (2017). An early years toolbox for assessing early executive function, language, self-Regulation, and social development validity, reliability, and preliminary norms. *Journal of Psychoeducational Assessment*, *35*(3), 225–275. http://dx.doi.org/10.1177/0734282916633009

Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2005). *Applied linear statistical models*. McGraw-Hill Irwin.

Li, Q., Liu, P., Yan, N., & Feng, T. (2020). Executive function training improves emotional competence for preschool children: The roles of inhibition control and working memory. *Frontiers in Psychology*, *11*(347), 1–11. http://dx.doi.org/10.3389/fpsyg.2020.00347

Lüdecke, D. https://cran.r-project.org/web/packages/esc/esc.pdf, 2018

Ministerio de Educación y Formación Profesional. (2020). *Educación infantil* http://www.educacionyfp.gob.es/va/contenidos/estudiantes/educacion-infantil.html#:~:text=La%20Educaci%C3%B3n%20Infantil%20es%20la,3%20a%20los%206%20a%C3%B1os.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. http://dx.doi.org/10.1006/cogp.1999.0734

Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., & Team, R. C. (2013). Nlme: Linear and nonlinear mixed effects models. *R Package Version*, *3*(1), 111–131.

Raver, C. C., Jones, S. M., Li-Grining, C., Zhai, F., Bub, K., & Pressler, E. (2011). CSRP's impact on low-income preschoolers' preacademic skills: Self-regulation as a mediating mechanism. *Child Development*, *82*(1), 362–378. http://dx.doi.org/10.1111/j.1467-8624.2010.01561.x

Röthlisberger, M., Neuenschwander, R., Cimeli, P., Michel, E., & Roebers, C. M. (2012). Improving executive functions in 5 and 6 year-olds: Evaluation of a small group intervention in prekindergarten and kindergarten children. *Infant and Child Development*, *21*(4), 411–429. http://dx.doi.org/10.1002/icd.752

Rueda, M. R., Checa, P., & Combita, L. M. (2012). Enhanced efficiency of the executive attention network after training in preschool children: Immediate changes and effects after two months. *Developmental Cognitive Neuroscience*, *2*, 192–204. http://dx.doi.org/10.1016/j.dcn.2011.09.004

Rueda, M. R., Rothbart, M. K., McCandliss, B. D., Saccomanno, L., & Posner, M. I. (2005). Training, maturation, and genetic influences on the development of executive attention. *Proceedings of the National Academy of Sciences*, *102*(41), 14931–14936. http://dx.doi.org/10.1073/pnas.0506897102

Santa-Cruz, C., & Rosas, R. (2017). Mapping of executive functions. *Estudios de Psicología*, *38*(2), 284–310. http://dx.doi.org/10.1080/02109395.2017.1311459

Thorell, L. B., Lindqvist, S., Bergman Nutley, S., Bohlin, G., & Klingberg, T. (2009). Training and transfer effects of executive functions in preschool children. *Developmental Science*, *12*(1), 106–113. http://dx.doi.org/10.1111/j.1467-7687.2008.00745.x

Traverso, L., Viterbori, P., & Usai, M. C. (2015). Improving executive function in childhood: Evaluation of a training intervention for 5-year-old children. *Frontiers in Psychology*, *6*(525), 1–14. http://dx.doi.org/10.3389/fpsyg.2015.00525

Traverso, L., Viterbori, P., & Usai, M. C. (2019). Effectiveness of an executive function training in Italian preschool educational services and far transfer effects to pre-academic skills. *Frontiers in Psychology*, *10*(2053), 1–15. http://dx.doi.org/10.3389/fpsyg.2019.02053

Walk, L. M., Evers, W. F., Quante, S., & Hille, K. (2018). Evaluation of a teacher training program to enhance executive functions in preschool children. *Plos One*, *13*(5), 1–20. http://dx.doi.org/10.1371/journal.pone.0197454