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Effect of a Chess Training Program on the Development of the Executive Functions in Primary School

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A B S T R A C T

Executive functions are higher cognitive abilities that allow the control of behaviour, cognition, and emotions. The present study analyses if a chess training program helps to develop the executive functions, and if these improvements are transferable to activities in daily life. To accomplish this purpose a quasi-experimental approach was designed. Two groups of children aged between 8 and 12 years were compared. The experimental group attended a chess workshop. The control group attended another educational workshop with the same frequency and duration as the experimental group. The BRIEF-2 test was applied to both groups, families and teachers of the boys and girls before and after the workshops. The results showed that the children in the experimental group improved in the executive functions evaluated by teacher perception but not by parental perception, and the control group did not present any relevant significant improvement. In the discussion, we comment on these results.

El efecto de un programa de entrenamiento de ajedrez en el desarrollo de las funciones ejecutivas en Educación Primaria

Palabras clave:
Funciones ejecutivas
Programa de entrenamiento de ajedrez
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R E S U M E N

Las funciones ejecutivas son capacidades cognitivas superiores que permiten el control del comportamiento, la cognición y las emociones. El presente estudio analiza si un programa de entrenamiento de ajedrez contribuye al desarrollo de las funciones ejecutivas y si estas mejoras son transferibles a actividades de la vida diaria. Para ello, se diseñó un enfoque cuasiexperimental en el que se compararon dos grupos de niños y niñas de edades comprendidas entre 8 y 12 años. El grupo experimental asistió a un taller de ajedrez, mientras que el grupo control participó en otro taller educativo con la misma frecuencia y duración que el grupo experimental. Se aplicó el test BRIEF-2 a las familias y al profesorado de los niños y niñas participantes antes y después de los talleres. Los resultados mostraron que los niños y niñas del grupo experimental mejoraron en las funciones ejecutivas evaluadas según la percepción del profesorado, pero no según la percepción de las familias. El grupo control no presentó mejoras significativas relevantes. En la discusión se comentan estos resultados.

Executive functions refer to the set of processes underlying the control of behaviour, cognition, and emotions. More specifically, they consist of higher order cognitive functions that allow the regulation of goal-directed behaviours. Although up to 33 different functions have been proposed, there is a certain consensus that there are three basic types: working memory, cognitive flexibility, and inhibition (Huizinga et al., 2006; Lehto et al., 2003; Miyake et al., 2000). Working memory involves holding and manipulating information in mind that is no longer perceptually present (Diamond, 2013). Cognitive flexibility is defined as the ability to change between different mental perspectives or enlist in or interrupt a task depending on the requirements needed to complete it (Ionescu, 2012). Inhibition is understood as the capacity to retain a dominant, automatic, or comfortable response when another behaviour that is more adapted to the requirements of the situation must be carried out (Tiego et al., 2018). To these three basic executive functions Diamond (2013) adds two higher order functions, fluid intelligence and planning. Executive functions have been shown to be the basis for academic achievement (Jacob & Parkinson, 2015), but, more importantly, they are fundamental for coping with situations that arise throughout life's journey (Diamond, 2013). In this sense, they are considered essential for physical and mental well-being and the development of the socio-cognitive skills of children and adolescents (Karbach, 2015).

Several studies have shown that executive functions can be trained (Diamond & Ling, 2020). In this way, the main goal of the training programs, understood as the extended practice on cognitive

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task process, is to establish transfer of training to contexts beyond the trained tasks precisely by performing demanding tasks in that domain (Jolles & Crone, 2012). Transfer can occur when a set of trained skills effects other domains that are strictly related (near transfer) or when trained skills and the other domains are only loosely related (far transfer) (Sandberg et al., 2023). So, near transfer refers to improvements on different tasks measuring the same function, and far transfer includes generalization to other functions or even improvements in daily life (de Vries et al., 2021).

Several studies have demonstrated near transfer of training effects to tasks within the same domain (Rennie et al., 2021; Thibault et al., 2021). However, transfer effects are highly inconsistent across studies, and the exact variables that lead to the transfer effects are still unclear (Jolles & Crone, 2012; Sala et al., 2019). A critical aspect of training benefits is the transfer of training effects to real-life situations. In that line, the most promising results in daily activities take place when there are fostered programs that focus first in the attentional processes and secondly in setting tasks which develop all the executive functions in general (Karbach & Unger, 2014; Kray & Ferdinand, 2013; Morrison & Chein, 2011). So, in fact, it seems that the training programs that are more likely of real world scenarios can have a major impact on the development of a wide range of cognitive skills, especially in those which are quite similar to the trained tasks, and throughout the life (Diamond & Ling, 2020; Jaeggi et al., 2008).

In this line of research, chess has been proposed as a tool that could help to develop executive functions because it requires the activation of attentional processes and also involves a lot of other cognitive skills that are essential for our daily lives. For instance, during a chess game attention and inhibition are required, because we need to consider not playing the first move that comes to our mind (Gindi & Pilpel, 2020; Ramos et al., 2018), planning and working memory to mentally calculate all the sequence of the chess variants that offers the position (Bart, 2014; Unterrainer et al., 2006), and cognitive flexibility to rapidly deal with the unexpected moves and strategies of the opponent (Gliga & Fesner, 2014; Grau-Pérez & Moreira, 2017; Rojas, 2011). All of these cognitive skills make chess a tool that has the potential to be a fantastic strategy-based training because it promotes the chess ability and a general way of doing and thinking that may serve as an effective resource in new life situations (de Vries et al., 2021).

Indeed, different studies have shown that training chess improves some academic skills (Bart, 2014; Kazemi et al., 2012). More specifically, a moderate positive effect has been observed for maths and a more modest effect for reading (Rosholm et al., 2017; Saurina & Serra, 2020; Trinchero, 2013). Also, it has been shown that chess could be a very useful instrument to help academic performance in children with special educational needs (Barrett & Fish, 2011) and in students at risk of academic failure (Hong & Bart, 2007). These studies therefore show that the skills required in chess are transferable to other dimensions beyond the game itself. This could be because chess requires cognitive abilities underpinned to different domains and skills, which could include the executive functions. In this line, various contributions with children between 7 and 16 years have previously demonstrated that playing chess on an ongoing basis produces improvements in the different executive functions: flexibility and planning (Grau-Pérez & Moreira, 2017; Ramos et al., 2018; Rojas, 2011), response inhibition (Gindi & Pilpel, 2020), and cognitive and socioaffective competencies (Aciego et al., 2016). Furthermore, and by way of example, chess has also been used as a therapeutic instrument to treat the attention deficit and hyperactivity disorder (ADHD; Blasco et al., 2015), cocaine addiction (Gonçalves et al., 2014), schizophrenia (Demily et al., 2009), and the prevention of dementia (Dowd & Davidhizar, 2003).

Despite this empirical evidence, the findings are not entirely conclusive. For example, Jerrim et al. (2018) found no evidence regarding the positive effects of chess instruction on other cognitive domains, and Sala and Gobet's (2016) conclusions are very similar except for a small correlation between the use of chess and some improvements on mathematics. The sample of both studies include pupils from kindergarten to the 12th grade. In a similar way, Bilalić et al. (2007) do not find a correlation between fluid intelligence and chess. In this sense, Sala et al. (2017) comment that further research and a rigorous experimental design is required to see the impact of chess in the different domains.

On the other hand, currently there are two relevant issues in the study of experimental programs to aid the development of executive functions. The first one is the degree of transference of these programs to daily life, and the second one is the degree to which the programs transfer to other types of functions and to other academic fields such as learning maths, languages, and literacy (Diamond & Ling, 2016; Redick et al., 2015; Traverso et al., 2019).

Taking the previous points into account, we will focus the study on the effect of the chess game on the executive functions.

To this end, we propose a quasi-experimental study to assess the executive functions of two groups of children aged 8 to 12 years. One group, called the intervention group, receives chess training for five months over approximately 48 hours, while the other group, the control group, also receives various training in other subjects proposed by the school during the same period and for the same number of hours.

The hypotheses formulated are as follows:

1. The pupils in the group that attend the chess sessions undergo a significant improvement in executive functions compared to the state before the sessions and the control group.

2. Improvements in executive functions will be transferred to daily life contexts such as school and home.

Method

Participants

In this study a sample of 40 children aged between 8 and 12 years was used. The selected children attended the School [school name] in [city name].

The school offers different training workshops for 3 hours per week for 4-months (technology, artistic creation, cooking, sport, sewing and maintaining and creating spaces in the school). At the beginning of the school year, the boys and girls completed a questionnaire in which they were invited to participate in one of the workshops offered by the school. The pupils selected two options in order of preference and they were assigned to the group requested. The decision to attend these workshops was taken by the pupils themselves and their families.

We used a quasi-experimental approach in which the 20 participants who attended the chess workshop form the experimental group. This training workshop lasts about 48 hours, so they attended more than 25 hours of chess practice which is the minimum to reach transference effects to other domains (Sala & Gobet, 2016). In this group there were 13 boys (65%) and 7 girls (35%). The mean age of the group was 10.05 (*SD* = 0.99) years. The other 20 pupils in the sample received different types of training in a similar way through the different school workshops, for the same number of hours per week and number of weeks, and were the students who form the control group. The control group was selected between the students of the different workshops, so that there were the same proportions of boys and girls so that they were similar ages of the boys and girls in the experimental group who attended the chess workshop. The average age in the control group was of 9.80 (*SD* = 0.83) years.

All the pupils in the sample received the same formal chess training at the school before starting the intervention because the school implements one hour per week of chess as a compulsory subject from the first to the sixth grade of primary school.

In addition, to verify that the groups analysed were comparable, the propensity score was subsequently applied to the resulting groups. For the intervention group the mean was 0.49 (*SD* = 0.08) and for the control group the mean was 0.51 (*SD* = 0.06). The similarity for the values of the propensity scores suggests that the groups are comparable in terms of baseline characteristics.

To calculate the propensity score we used the only prior information we had: age and sex. It would be very interesting to consider other types of variables to achieve a better design, but our research was carried out in a school and the boys and girls in the experimental group were the students who voluntarily decided to take this chess training workshop

Instruments

The executive functions were analysed using the Spanish version of the BRIEF-2 questionnaire for parents and teachers (Maldonado et al., 2017). This instrument assesses executive function using nine clinical scales: inhibition (both behavioural and emotional), self-monitoring, flexibility, emotional control, initiative, working memory, planning and organization, task supervision, and organization of materials. It also provides three general indices: behavioural regulation index, emotional regulation index, cognitive regulation index, and a global index of executive function.

There are two charts for collecting information (BRIEF-2 Family and BRIEF-2 School), which can be applied separately or together, facilitating the assessment of executive functions by parents and teachers. The transformed scale score with a mean of 50 and a standard deviation of 10 was used to interpret the results, allowing us to compare the results obtained with those of a normative sample of the general population of the same age and sex. The higher the value of the score, the worse the result for the indicator. The BRIEF-2 is one of the most frequently used instruments in research to evaluate executive functions and the internal consistency coefficients of the BRIEF-2 scores obtained in several studies with large samples (n > 500) of the Spanish adaptation is .86. (Maldonado et al, 2017).

Design and Procedure for Collecting Data

First, prior to applying the test the consent of the school and the families was obtained. Once this procedure had been completed, the BRIEF-2 questionnaire was administered to both the parents and the teachers of each of the pupils of the two groups, one made up of the pupils that were to participate in the chess training workshop and the other made up of those who were to participate in the other workshops. The instructions were very simple to follow, but if clarification of any kind regarding the questions themselves or how the test worked was needed, they were able contact to the researchers. They were given a week to hand in the fully completed questionnaires. This entire process was carried out during the first weeks of September, before the pupils started the corresponding workshops.

Between October and February, the children in the experimental group attended the chess workshop and the other children attended the different workshops. The chess workshop was conducted using the “observe, think, and play” principle, which can be applied not only in a chess game but also to daily life. The idea is to establish a shared philosophy between these two contexts, highlighting that in both it is necessary to pay attention to what surrounds us, then analyze the different options, and finally act accordingly (or make our move on the chessboard). The idea was to teach the intricacies of the game in a didactic and pedagogical way by using activities and problem-solving strategies based on the moves of the pieces, that prioritise reflection and reasoning abilities, rather than only playing chess games. As mentioned earlier, the workshop spans 48 hours, distributed as three hours per week over four months, with a gradual increase in the difficulty of the sessions.

Once the workshops were finished, the BRIEF-2 questionnaires were once again administered to teachers and families. The procedure used was the same as the first time the questionnaire was administered.

All the evaluations made in this paper are based on the profiles obtained from the BRIEF-2 questionnaire, which reflected the perceptions of the families and the teachers of the participating pupils.

Statistical Analysis

Having received all the answers, we proceeded to carry out a comparative analysis of the answers obtained for the children in the two groups to evaluate whether there were any similarities or significant differences in the values obtained for the executive functions before starting the intervention. The means comparison test for independent samples was applied, controlling the heterogeneity of the variance using the Levene’s (1960) test. The same comparative analysis was made of the results obtained for the two groups once the workshops were completed. In both cases, the test was carried out for all 13 results provided by the BRIEF-2 and for the information elicited from both the families and teachers.

Since we were working with small samples and with values that were non-normally distributed, the Wilcoxon signed-rank test was performed to verify the robustness of the results of the parametric tests (Conover, 1973; Zimmerman, 1997). All the analyses were carried out using IBM SPSS Statistics version 25. The Cohen’s d was calculated to measure the size effect of the significant differences found in the test re-test (Cohen, 1969).

After that, in order to compare the variations over time between the two groups, we proceeded to apply the ANOVA model with repeated measures for each of the indicators and for both the results obtained by the school and those obtained by the families (Huck & McLean, 1975). The between-subject factor is the pre-post difference obtained for each of the indicators and as within-subject factors we introduced the group (intervention-control) and the age factor (8 to 10 years - 11 to 12 years).

Finally, a test-retest study was carried out in order to know separately the trajectory of the intervention group and the control group and to detect the significant differences in the different scales and indices provided by the BRIEF-2 before and after the assistance in the workshops. Because we had two sets of parent and teacher responses for each child at the two time points, we were able to conduct paired mean comparison tests for the nine scales and four indices that comprise the test for students in the intervention group and for students in the control group.

Results

The results obtained for the comparison of means tests for independent samples applied to the two different groups before and after are shown in Table 1. The comparison of scores before the intervention allows us to see statistically significant differences in both the responses of teachers and parents.

For the experimental group, the initial assessments of the teachers only show statistically significant differences at 95% for the indicators of flexibility (differences experimental-control group = 12.45 points, p = .001; Cohen’s d = 1.179) and initiative (differences experimental-control group = 9.00 points p = .011; Cohen’s d = 0.848) in the sense of worse results compared to the control group. Regarding the initial assessments of the families, no significant differences were observed.

The comparison of executive function scores after the workshops for

Table 1. Evaluation of the pre- and post-differences between Experimental and Control Group Scores

	Evaluation of the initial differences between groups				Evaluation of the post-training differences between groups			
	Experimental Group	Control Group			Experimental Group	Control Group		
	Pre-mean (*SD*)	Pre-mean (*SD*)	*p*-value	Cohen's *d*	Post-mean (*SD*)	Post-mean (*SD*)	p-value	Cohen's *d*
School								
Inhibition	57.30 (17.07)	52.30 (11.11)	.280	0.347	49.65 (11.30)	47.15 (7.04)	.406	0.266
Supervising oneself	54.30 (12.82)	48.35 (9.44)	.103	0.528	48.35 (8.73)	44.00 (3.58)	.050*	0.652
Flexibility	58.80 (11.99)	46.35 (8.89)	.001***	1.179	49.45 (8.98)	43.35 (5.08)	.012**	0.836
Emotional control	54.20 (14.41)	47.05 (6.61)	.054*	0.638	47.45 (8.11)	43.90 (2.29)	.073*	0.596
Initiative	61.00 (12.03)	52.00 (8.96)	.011**	0.848	53.35 (11.93)	51.35 (9.03)	.553	0.189
Planning and organisation	60.20 (13.18)	52.45 (10.99)	.050*	0.639	54.25 (9.18)	50.70 (7.46)	.187	0.425
Working memory	61.90 (14.52)	54.45 (12.91)	.095*	0.542	55.40 (13.59)	52.95 (8.72)	.502	0.215
Task supervision	61.05 (11.27)	55.20 (10.32)	.095*	0.541	56.05 (10.80)	51.20 (8.18)	.118	0.506
Organisation of materials	64.05 (13.90)	57.55 (14.08)	.150	0.465	55.40 (9.14)	51.90 (8.52)	.218	0.396
Behavioural regulation index	56.55 (15.83)	50.75 (9.40)	.169	0.444	49.10 (10.13)	45.60 (5.13)	.179	0.436
Emotion regulation index	57.25 (13.03)	46.40 (7.86)	.003***	1.008	48.30 (8.53)	42.95 (3.47)	.015**	0.822
Cognitive regulation index	62.75 (13.60)	54.70 (11.93)	.054*	0.629	55.40 (11.35)	51.60 (8.36)	.241	0.376
Global index of executive function	61.45 (14.08)	52.15 (9.81)	.021**	0.766	52.85 (9.22)	48.15 (5.89)	.076*	0.576
Family								
Inhibition	56.17 (11.94)	49.78 (9.60)	.086*	0.590	54.45 (10.13)	49.44 (7.83)	.100	0.549
Supervising oneself	55.06 (11.78)	51.94 (8.26)	.365	0.306	54.00 (9.35)	51.44 (6.70)	.351	0.307
Flexibility	56.94 (8.76)	57.39 (8.21)	.876	-0.052	55.70 (9.85)	54.11 (9.32)	.614	0.165
Emotional control	53.83 (10.61)	55.67 (9.37)	.586	-0.183	52.60 (9.25)	52.17 (7.25)	.872	0.052
Initiative	52.89 (8.93)	51.39 (8.76)	.614	0.170	52.50 (7.80)	54.50 (11.94)	.541	-0.201
Planning and organisation	56.39 (11.51)	55.29 (11.64)	.775	0.096	55.45 (9.55)	53.28 (9.85)	.495	0.224
Working memory	54.94 (10.69)	53.50 (11.12)	.694	0.132	55.15 (11.23)	50.50 (9.92)	.187	0.437
Task supervision	55.61 (11.29)	55.00 (8.86)	.858	0.060	53.25 (10.62)	51.56 (9.61)	.611	0.167
Organisation of materials	55.44 (12.62)	57.22 (13.35)	.684	-0.137	54.50 (10.79)	55.22 (10.97)	.838	-0.066
Behavioural regulation index	56.11 (12.29)	50.61 (9.09)	.136	0.509	54.50 (9.42)	50.00 (7.40)	.113	0.528
Emotion regulation index	55.83 (9.56)	57.44 (8.31)	.593	-0.180	54.40 (9.57)	53.33 (7.58)	.708	0.123
Cognitive regulation index	56.06(11.03)	55.28 (11.56)	.838	0.069	55.15 (9.74)	53.17 (10.57)	.551	0.196
Global index of executive function	56.89 (11.16)	55.44 (10.32)	.689	0.134	55.50 (9.47)	52.83 (8.68)	.373	0.293

Note. SD = standard deviation. Source: author's own elaboration.
*p < .10, **p < .05, ***p < .001.

the two groups, provided by the BRIEF-2, shows statistically significant differences only for the flexibility scale, although they are smaller than differences found initially (differences between the experimental and the control group = 6.10 points, p = .0112; Cohen's d = 0.836). Regarding parent evaluations, however, there were no significant differences between the two groups after taking part in the workshops. This reduction in the initial differences between the two groups, together with the weak effect size of the improvements observed in the control group, are factors that support the confirmation of the first hypothesis formulated.

The results of the ANOVA test with repeated measures of the teacher evaluation indicate a significant change over time in all indicators. The effect of the interaction factor with time (pre-post) and group (control-intervention) shows significant interaction for the indicators of flexibility (p = .043, η^2 = .109) and initiative (p = .006, η^2 = .192). On the other hand, the effect of the interaction factor time (pre-post) with the age factor (8 to 10 years - 11 to 12 years) shows significant results for the Working Memory indicators (p = .052, η^2 = .101) and Task Supervision (p = .050, η^2 = .103).

In Figure 1 you can see how the evolution over time of the flexibility and initiative indicators shows how the boys and girls in the experimental group improve much more than the boys and girls in the control group.

In Figure 2, where we have all the students regardless of the workshop they attended, it can be observed how the temporal evolution of the working memory and task supervision indicators obviously show a greater improvement for older boys and girls (from11 to 12 years old).

The results applied to the evaluation of families only detect significant results in the task supervision indicator (p = .014, η^2 = .186) in the sense that a change is observed over time. None of the indicators of executive functions show a significant interaction between time (pre-post) and the factors group and age.

The comparison of means in the test re-test for paired data, which are the tests that indicate whether the application of the BRIEF-2 test after the workshops had uncovered any changes in the set of executive functions separately in any of the two groups: intervention and control, are shown in Table 2.

The teacher evaluation of the experimental group showed a statistically significant improvement up to a 95% confidence level for all the indicators of the executive functions. The reduction in the mean scores of the differences, together with their standard deviation and the level of significance of the test, was observed for each indicator. We also calculated the effect size, based on the Cohen's d, to evaluate the importance of the significant changes and to correctly interpret the changes found.

For the experimental group, the effect size of the answers given by the teachers showed a medium effect in most of the indicators, a weak effect, in the case of task supervision and on the working memory scale, and a large effect in the case of the flexibility scale and the emotion regulation index. These results confirm the second hypothesis posed for the evaluations made by the teachers.

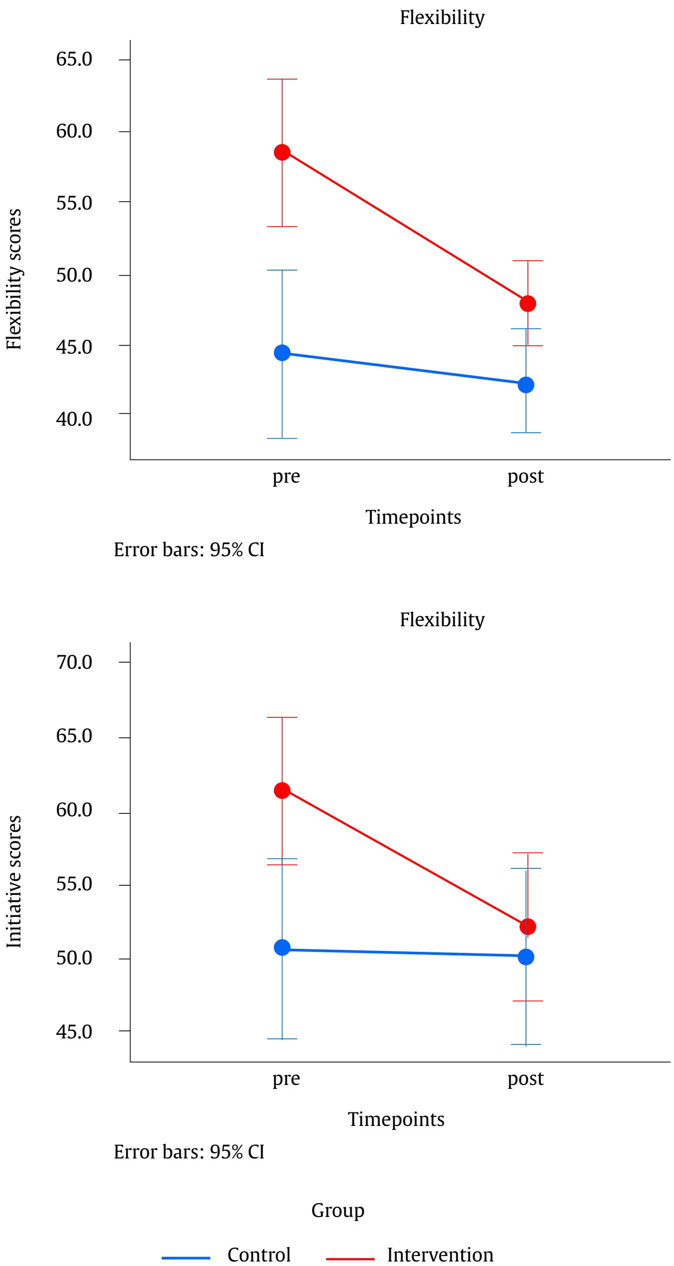

Figure 1. Evolution over Time of the Flexibility and Initiative Indicators.

Statistically significant improvements up to 95% of confidence in five of the nine executive function scales and in the behavioural regulation index were observed for the children in the control group. No improvements were observed in the flexibility, initiative, planning and organisation, and working memory scales. Another point of interest is that where there were significant improvements in the indicators mean differences between the scores obtained before and after attending the workshop were smaller than mean differences observed for the pupils in the experimental group. We highlight the differences in the flexibility indicator (experimental group variation = 9.35 points, p = .006; Cohen's d = 0.883 and control group variation = 3.00 points, p = .144; Cohen's d = 0.414) and in the initiative indicator (experimental group variation = 7.65 points, p = 0.002; Cohen's d = 0.639 and control group variation = 0.65 points, p = .702; Cohen's d = 0.072) matching the significant interaction factor time (pre-post) and group (intervention-control) in the ANOVA test. Furthermore, the effect size of the significant differences observed in the control group shows a weak effect for supervision of tasks, organisation of materials, and the cognitive regulation index, and a medium effect for inhibition, supervision of oneself, emotional control, and the emotion regulation and behavioural regulation indices.

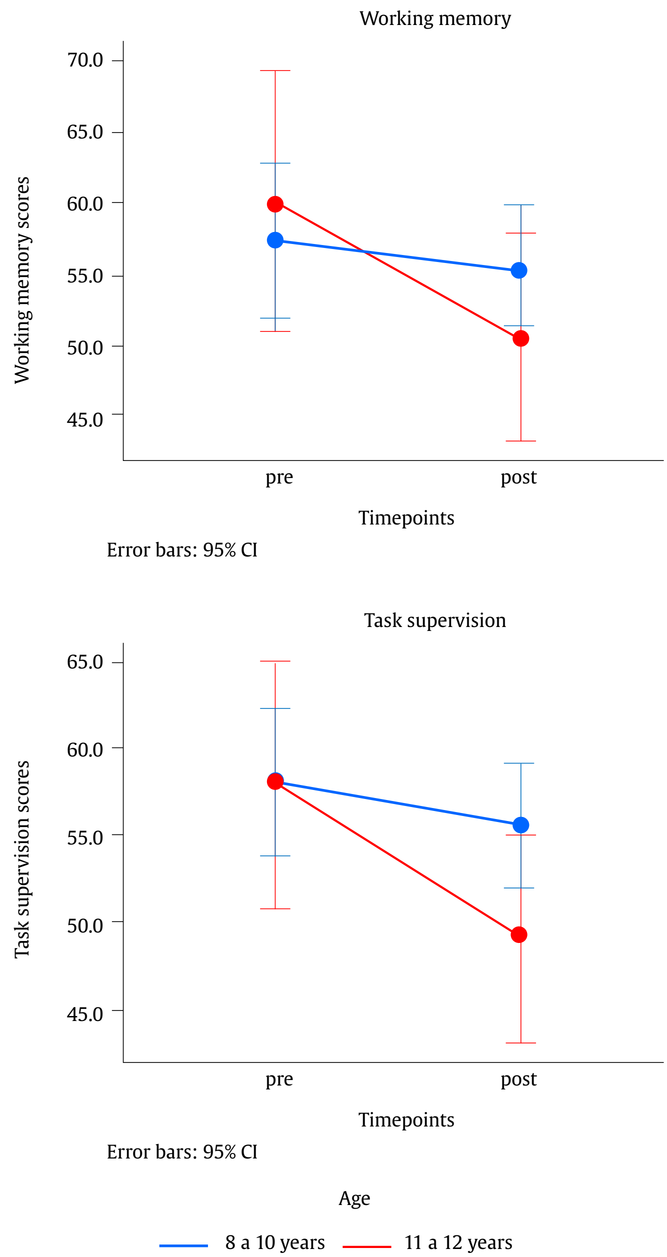

Figure 2. Evolution over Time of the Working Memory and Task Supervision Indicators by Age Ranges.

Very different results were obtained for the evaluation provided by the families, using the same criteria as for the teacher evaluation. Lower values for the differences in the scores obtained were observed for both groups, indicating that no major differences were identified. No statistically significant differences at all were found for the experimental group, whereas significant differences at 95% with a weak size effect were observed for the control group in the task supervision scale and the emotion regulation index. This change identified by families with respect to the task supervision indicator in the case of the control group was also generally detected in the AOVA test. Interestingly, some negative

Table 2. Evaluation of Differences before and after the Intervention for the Experimental and the Control Groups

	Experimental Group			Control Group		
	Mean (*SD*)	*p*-value	Cohen's *d*	Mean (*SD*)	*p*-value	Cohen's *d*
School						
Inhibition	7.65 (11.78)	.009 ***	0.528 B	5.15 (6.30)	.002***	0.554 B
Supervising oneself	5.95 (11.15)	.028**	0.543 B	4.35 (9.00)	.044**	0.600 B
Flexibility	9.35 (13.59)	.006***	0.883 A	3.00 (8.81)	.144	0.414 C
Emotional control	6.75 (11.61)	.018**	0.577 B	3.15 (6.05)	.031**	0.637 B
Initiative	7.65 (9.54)	.002***	0.639 B	0.65 (7.47)	.702	0.072
Planning and organisation	5.95 (9.33)	.010**	0.524 B	1.75 (7.52)	.311	0.186
Working memory	6.50 (12.75)	.034**	0.462 C	1.50 (8.21)	.424	0.136
Task supervision	5.00 (9.77)	.034 **	0.453 C	4.00 (7.49)	.027**	0.430 C
Organisation of materials	8.65 (12.25)	.005***	0.735 B	5.65 (10.99)	.033**	0.486 C
Behavioural regulation index	7.45 (11.55)	.009 ***	0.561 B	5.15 (7.04)	.004***	0.680 B
Emotion regulation index	8.95 (12.25)	.004***	0.813 A	3.45 (7.56)	.055*	0.568 B
Cognitive regulation index	7.35 (10.12)	.004***	0.587 B	3.05 (7.58)	.088*	0.296 C
Global index of executive function	8.60 (11.11)	.003***	0.706 B	4.00 (6.96)	.019**	0.494 C
Family						
Inhibition	1.22 (6.12)	.409	0.111	-1.38 (5.89)	.365	0.164
Supervising oneself	1.22 (9.03)	.573	0.112	-2.00 (5.79)	.187	0.281 C
Flexibility	0.44 (8.34)	.824	0.047	3.75 (8.09)	.083*	0.447 C
Emotional control	1.17 (7.45)	.515	0.121	2.38 (4.95)	.074*	0.279 C
Initiative	0.61 (9.49)	.788	0.072	-4.25 (9.68)	.099*	0.399 C
Planning and organisation	1.00 (6.24)	.506	0.095	1.31 (6.81)	.453	0.122
Working memory	0.83 (4.44)	.436	0.078	1.69 (6.77)	.335	0.165
Task supervision	2.72 (6.81)	.108	0.243C	3.88 (6.91)	.040**	0.410 C
Organisation of materials	1.89 (8.98)	.385	0.060	0.75 (7.61)	.699	0.066
Behavioural regulation index	1.39 (6.08)	.346	0.127	-1.69 (4.27)	.135	0.219 C
Emotion regulation index	1.06 (6.34)	.489	0.113	3.56 (6.25)	.038**	0.443 C
Cognitive regulation index	1.56 (5.48)	.245	0.149	1.06 (5.87)	.480	0.097
Global index of executive function	1.61 (5.87)	.261	0.155	1.31 (4.98)	.308	0.142

Note. SD = standard deviation. Cohen's *d*: A = $d > 0.80$, B = $0.50 < d < 0.80$, C = $0.20 < d < 0.50$. Source: author's own elaboration.
*$p < .05$, **$p < .01$, ***$p < .001$

values were also noted for this group for the difference of means in some of the indicators, implying a perception of worsening of some of the executive functions, although none were significant at 95% of confidence. Consequently, the second hypothesis has been only confirmed in the school but not for the families.

Discussion

Current research on executive functions demonstrates that they are developable and trainable. Diamond and Ling (2020), in their review of 179 studies from around the world, highlight the trainability of executive functions through various interventions, achieving different levels of effectiveness. However, their review did not include chess. Our study therefore contributes to this body of research by exploring the potential of chess to improve executive functions in children, particularly given the mixed evidence of its impact on academic and cognitive performance (Sala & Gobet, 2016).

The use of the BRIEF questionnaire allowed us to assess executive functions in children's natural contexts—both at home and at school—through the evaluations of parents and teachers. The results confirm our hypothesis. In the first one, suggesting that chess develops executive functions, a largest effect size was observed in the Flexibility scale and in the Emotion Regulation index. These results reinforce previous findings by Rojas (2011) and Grau-Pérez and Moreira (2017), who also reported improvements in cognitive flexibility through different types of cognitive training in children between 7 and 12 years. Aciego et al. (2016) found better results in socio-emotional competencies among students between 6 and 16 years who play chess in comparison of basketball. On the other hand, the second hypothesis, that indicates Improvements in executive functions will be transferred to daily life contexts, is only partially confirmed as the findings suggest that improvements have only been observed in the evaluations made by the teachers. These results are similar to other studies that also find evidence that a program based on chess instruction can enhance the academic performance (Ortiz-Pulido et al., 2019; Poston & Vandenkieboom, 2019; Rosholm et al., 2017; Trinchero, 2013).

Actually, the results of the before and after parental evaluations were somewhat inconclusive for both groups. No significant differences were found at all for the experimental group, and the few differences for the control group showed small effect sizes. These results can illustrate that probably the school environment requires executive functions processes to a greater extent than at home. Thus, since chess requires attention, analysis, and decision-making skills that are also integral to academic performance, this may explain why teachers, who observed children in a context where these skills are regularly applied, noted greater improvements. These findings suggest that perception of the executive functions probably depends on the context, the activities being evaluated, the role of the evaluator, and the specific training methods used.

Referring to different types of cognitive training, some meta-analyses found little or no evidence about the far transfer effects that these programs are susceptible to develop (Gobet & Sala, 2023; Kassai et al., 2019). In that way, its main conclusion is that, considering the absence of benefits that generalize beyond the trained components, it is not effective to train specific executive function skills in isolation. However, a training program based on chess has the potential to overcome these limitations. Chess is a game that promote higher-order thinking skills, such as concentration, spatial reasoning, problem-solving, the capacity to predict and anticipate consequences and critical thinking, because it is considered that all of these skills are needed, and could be developed, by specific training during a chess game (Rosholm et al., 2017; Trinchero & Sala, 2016). Thus, this capacity to develop such different executive functions at the same time, makes chess a potential tool to provoke transfer effects to different domains.

In this respect, we have already commented that there are currently two relevant issues in the study of experimental programs to aid the development of executive functions: the strictly improvements of these executive functions and their degree of transference to daily life (Diamond & Ling, 2016; Redick et al., 2015; Traverso et al., 2019). So, in terms of learning, it has been argued that the more similar the cognitive training is to the task, the more benefits can be achieved. Therefore, one hypothesis to explain the transfer effects is the functional overlap. Specifically, if two tasks overlap in the cognitive processes they demand, any gains in these underlying processes should transfer from training in one task to performing the other task, so that strengthening these processes during training will benefit performance in transfer situations (Jiang et al., 2023). As hypothesized before, this thesis may explain why teachers in the school context have found some improvements.

Finally, we consider that our study provides some interesting reflections on which populations could benefit most from playing chess as a tool for the mind to develop executive functions (Bodrova et al., 2011). In fact, the children in this study did not start at the same level of development of the executive functions, with the control group showing best scores than the experimental group. While no conclusive statements can be made, it does suggest that the pupils that could benefit most from playing chess are those with lower executive functions. As pointed out in the introduction, chess is already used for therapeutic ends, so this point would need to be further explored. Meanwhile, current studies on cognitive training are a very promising line of research for the possible transference effects to real world areas and scenarios (Schubert et al., 2014), and it is in this sense that chess should be a tool to consider.

Limitations and Future Directions

We want to note that we have used a convenience sample taking advantage of a chess intervention at school. This decision responds to the dynamics of the school itself, because for the experimental group, we had to select the only 20 pupils who attended the chess workshop. In future research, it would be convenient to work with larger samples and to add a control group that does not attend any workshop. Finally, it would be useful to implement a tracking that allows us to collect new data to verify if the improvements achieved are maintained over time.

Conclusions

In summary, we can state that all the executive functions evaluated in the BRIEF improved significantly for the group of pupils that actively participated in the chess workshop, from the teachers' point of view. Specifically, the most important improvements take place in the indicators of flexibility and in the emotion regulation index. To a lesser extent, improvements took place in initiative, organisation of materials, and in the global index of executive function scales.

Finally, we would like to point out that our study contributes to the knowledge about the implications of an intervention based on chess for the development of executive functions. All in all, the results suggest that chess could be more useful for the group of students who start from lower levels and therefore chess is envisaged as a good instrument for intervention in vulnerable groups.

Conflict of Interest

The authors of this article declare no conflict of interest.

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