Empirical Article

Executive functions are important for academic achievement, but emotional intelligence too

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Perpiñà Martí, G., Sidera, F., Senar Morera, F. & Serrat Sellabona, E. (2023). Executive functions are important for academic achievement, but emotional intelligence too. *Scandinavian Journal of Psychology.*

Finding predictors of academic achievement has caught the interest of many educational researchers in the last decades. Two of the variables that have received considerable attention are emotional intelligence (EI) and executive functions (EF). However, only a few studies have considered their influence in the primary school stage. The aim of this study is to identify which EI components and specific EF are most related to academic achievement and to explore if these relationships vary among subjects. The sample comprised of 180 students between 8–11 years old. We administered the BarOn EI Inventory, tasks of EF and tests of mathematic and linguistic competences. The results showed that EF are better predictors of school performance than EI. Inhibition and working memory were the EF most associated with achievement while adaptability emerged as the EI dimension most linked to it. This study suggests that EI and EF should be consciously developed in classrooms.

Key words: emotional intelligence, executive functions, academic achievement, primary education, mathematics, language.

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INTRODUCTION

In the last years, due to the increasing importance of school success, educational researchers have focused their attention on finding potential predictors of academic achievement in elementary and high school, including variables such as self-esteem, personality, emotional intelligence, socio-economic status or executive functions (EFs) (Matešić, 2015). Two of the constructs that have emerged as strategic and have demonstrated to be determining factors of academic achievement are emotional intelligence (Droppert, Downey, Lomas *et al*., 2019; Parker, Creque, Barnhart *et al*., 2004; Zhoc, King, Chung & Chen, 2020) and executive functions (Ahmed, Tang, Waters & Davis-Kean, 2019; Blair & Razza, 2007; Magalhães, Carneiro, Limpo & Filipe, 2020). The aim of this article is to explore the predictive value of emotional intelligence (EI) and EFs for academic achievement, by identifying the specific factors that influence and predict students' achievement in the main school subjects: language and mathematics.

Emotional intelligence and academic achievement

The concept of EI and its association with school success have attracted the attention of numerous researchers, teachers and educational counsellors in the last decades. Nowadays, it has been established that there is a positive relationship between EI and academic achievement (Pulido-Acosta & Herrera-Clavero, 2018) and thus emotional abilities are important in the school context. MacCann, Jiang, Brown, Double, Bucich and Minbashian (2020), in a recent large-scale meta-analysis, found that EI is related to academic performance with an effect size similar to well-known non-cognitive predictors, such as motivation or personality.

Today, there is a broad consensus within the research community in accepting the existence of two different types of EI —trait and ability EI. Trait conceptualizations are based on self-report measures, and refer to our emotional perceptions: how good we believe we are in terms of perceiving, understanding, managing and utilizing our own and other people's emotions (Petrides, Sanchez-Ruiz, Siegling, Saklofske & Mavroveli, 2018). In contrast, ability models conceive EI as a cognitive competence, understood as the ability to provide correct responses to diverse emotional tasks, and evaluate it through performance tests. In consequence, trait EI is related to the personality area, whereas the ability EI to the cognitive field (González Yubero, Palomera Martín & Lázaro Visa, 2019). In this study, we will focus on trait EI because it is considered to influence the management of emotionally challenging school situations and consequently affect academic achievement.

One of the main conceptualizations of EI as a trait is the BarOn model, which defines emotional intelligence as a cross-section of interrelated competences that determine how effectively we understand and express ourselves, understand others and relate with them, and cope with daily demands (Bar-On & Parker, 2000). These socioemotional competencies are condensed in four key components: intrapersonal (the ability to recognize, understand and express emotions and feelings); interpersonal (the ability to understand how others feel and relate with them); stress management (the ability to manage and control emotions); and adaptability (the ability to manage change, adapt and solve problems).

According to MacCann *et al.* (2020) there are different mechanisms to explain the relationship between EI and academic achievement. The first one is related to managing negative emotions. This is, students with higher levels of EI are able to deal more easily with the negative emotions of the school context, such as boredom, anxiety or disappointment. The second mechanism is related to social skills. In this sense, emotionally intelligent students have more abilities to manage the social world around them, forming better relationships with teachers, peers and family. Finally, a third mechanism would be the possible overlap between EI competences and academic competences. Emotional content is more relevant to humanities-related subjects (where understanding motivations and emotions can be part of the assessable content), than in science or mathematics. In addition, IE could be involved in academic performance in a more indirect way, through study habits, family support or motivation levels (Petrides, Frederickson & Furnham, 2004).

All the above-mentioned mechanisms of influence between EI and academic achievement could be grouped in two types: those that help to develop school competences (e.g., certain interpersonal skills are necessary to develop an effective communicative competence) and those that enable to express properly the school competences (e.g., stress management skills could help to better express knowledge in an exam situation).

Focusing on primary education, Eastabrook, Duncan and Eldridge (2005) were among the first to find a positive relationship between EI and academic performance. Specifically, they found that students with higher qualifications in school also obtained higher scores on overall EI and on two of its subscales (interpersonal and adaptability). Similarly, Qualter, Whiteley, Hutchinson and Pope (2007) found that emotionally intelligent students obtained higher grades at the end of the school year. Finally, in a later study, Brouzos, Misailidi and Hadjimattheou (2014) did not find a correlation between Total EI and academic achievement, whereas the scores of the adaptability subscale of the EI correlated in a positive way with children's grades in Greek and mathematics.

Executive functions and academic achievement

Executive Functions (EFs) have also emerged as an important construct when studying the influences in academic achievement. EFs are comprised of different behavioral and cognitive elements related to self-control which play a significant role in learning and academic achievement.

The relation between EFs and academic performance may vary depending on the conceptualization of the former. EFs could directly influence student learning and achievement (i.e. having good level of inhibition is important for decoding correctly in a reading task). At the same time EFs could have a more indirect impact on school performance through learning–related behaviours, such as higher levels of involvement in the classroom or appropriate conducts (Nesbitt, Farran & Fuhs, 2015).

Diamond, Kirkham and Amso (2002) propose a model based on Miyake *et al.*'s (2000) three fundamental components of EFs: cognitive flexibility (CF)—described by Diamond *et al.* as adjustment to change, inhibitory control (IC)—resistance to distracters and working memory (WT)—mental manipulation of information. The influence of these core EF components on learning has been widely studied. Poor central executive functioning has been related to deficits in most of the scholastic domains, including literacy (e.g., Nouwens, Groen, Kleemans & Verhoeven, 2021) and arithmetic (Gashaj, Oberer, Mast & Roebers, 2019; Passolunghi & Siegel, 2001). In the field of mathematics, Clark, Pritchard and Woodward (2010) found that inhibition, cognitive flexibility and planning were all associated with improvement on mathematical achievement tests. Agostino, Johnson and Pascual-Leone (2010) only identified inhibition as the EF most related to problem solving ability; and Lee, Ee Lynn & Swee Fong (2009) reported that only working memory predicted achievement on algebra problems, but neither inhibition nor cognitive flexibility. Hence, the existing research has showed differing results regarding the components involved in the association EF-mathematics achievement. This could be attributed to the different conceptualizations of EFs, to the tasks administered to evaluate each of the components or to the population groups studied.

Working memory and cognitive flexibility are two of the EFs more associated to mathematic. According to Bull & Scerif (2001), working memory is associated with variability in strategy use and leads to more frequent use of the retrieval strategy, while cognitive flexibility is crucial for the child to flexibly apply different mathematical procedures to obtain correct mathematical solutions. The influence of these EFs is, according to them, more prominent in older school-age children than in preschool children. Espy et al. (2011) attributed these differences to the type of problems that children can solve at different ages. Mathematical problems faced by primary school children are likely to require maintaining information online for subsequent processing and responding. In contrast, mathematical problems for preschool children usually involve counting and simple regrouping, which do not demand as much working memory skills.

Regarding language, research has showed positive associations between inhibition and working memory and reading for young children (Chung & McBride-Chang, 2011; Foy & Mann, 2013). Specifically working memory and inhibition seem to be the EFs more related to reading comprehension. For example, Sesma, Mahone, Levine, Eason and Cutting (2009) found that students with reading comprehension problems had also significant deficits in working memory, and De Beni & Palladino (2000) concluded that 8-year-old poor comprehenders with adequate word-reading ability were significantly less able to inhibit irrelevant information on a working memory task than their better comprehending peers. Although cognitive flexibility is not considered a main predictor of language scores in most of the research done, its contribution to the development of reading comprehension is widely reported, as good readers must coordinate flexibly multiple aspects of reading tasks for successful comprehension (Cartwright, Marshall, Dandy, & Isaac, 2010).

THE PRESENT STUDY

The goal of this study is to examine the relationships between executive functions (EFs), emotional intelligence (EI) and academic achievement in a sample of primary school students (8–

11 years old) and determine to which extent EFs and EI contribute to school performance.

Most of the research done in this area has studied these constructs on high school and university samples and little is known about this relationship in younger ages. Therefore, it is possible that the relations of trait EI or EFs with academic achievements found so far may vary across school stages as well as across subjects.

Primary school is a period of important changes at the academic and personal level (Le Hoang & Grégoire, 2021; McCoy & Masters, 1985). Regarding executive functions, during the middle childhood these skills undergo a great development (Romine & Reynolds, 2005). In addition, this school stage requires significant cognitive and social adjustments: changes in instructional formats, increases in the number of teachers, changes in peer network, increased individual responsibility, etc. All these changes in the development of the emotional and cognitive competences suggest that it is worth considering the primary education stage in developmental studies that link emotion and cognition.

While the literature is clear about the existing relationships between EI and academic achievement and EFs and academic achievement, no published studies were found that have specifically examined the relationship of these three constructs together in primary school students. Understanding the importance of EI and EFs on academic achievement in this group is important for educational interventions.

This study builds on previous research in several ways. First, as previously said, the age of the sample. We assessed our predictions with young elementary students. This would allow us to see if the results found in high school and university samples could be generalized in younger ages, as well as to see if the effects of trait EI and EFs vary across educational levels. Second, we included a wide range of EI and EFs indicators as predictors; while prior studies mostly used overall scores of EI and EFs, only a few of them focused on the relations between the academic achievement with the different dimensions of the EI or with each specific EF. Thus, the present study explores the relative contribution of each of these predictors on children's performance at school. Third, whereas most of the previous studies have evaluated EI and EFs using reports of peers, parents or teachers, in the current study we used self-reports of assessing EI and hands-on tasks for evaluating EFs. Thus, the aims of the current study are:

1. To analyze in detail the relationships of EI and EFs with academic achievement, by considering not only overall scores but also their components.
2. To study whether these relationships vary among scholastic domains (literacy and mathematics).

Regarding the first objective, it is hypothesized that EF variables would have more power to predict academic achievement compared to EI variables, according to the last meta-analyses published (Pascual, Moyano & Robres, 2019; Perera & DiGiacomo, 2013; Schlegel, Palese, Mast, Rammsayer, Hall & Murphy, 2020). In the case of the other objective (objective 2), it is completely exploratory as this is the first study, to our knowledge, that analyses the role of these specific variables together to predict academic achievement.

METHOD

Participants

One hundred seventy three students between 8 and 11 years old participated in the study (M = 9.69; SD = 1.03). The sample was balanced in terms of grade (3rd: n = 83; 5th: n = 90) and gender (48% girls) and was recruited from two different schools in the province of Girona (Spain). The study used a convenience sample. The contact with the schools was done through an informative letter to their principals and schools were selected considering their similarity in terms of number of students and neighborhood. Participation rate was high, only 14 families did not give the consent to participate, which means the 6.8% of the total.

The Spanish education system in Primary Education is divided into initial cycle (1st and 2nd grades), middle cycle (3rd and 4th grades), and upper cycle (5th and 6th grades). The children in the study were in the first year of the middle cycle (3rd) and the upper cycle (5th) of primary education. The selection of grades was determined by taking into account that the participants had not been involved in the training or administration of the language proficiency tests usually administered by the Catalan government in the 4th and 6th grades—see next section.

Instruments

Emotional intelligence: The Spanish version of the BarOn Emotional Intelligence Inventory—EQi:YV (Bar-On & Parker, 2000) was used to evaluate students' emotional competence. This self-report instrument consists of 60 items divided in four scales (interpersonal, intrapersonal, stress management and adaptability) and provides a general score of EI as well as specific scores in each dimension. The reliability and validity of the BarOn – Eq:Yv has been widely established.

Executive functions: The inhibition subtest of the Nepsy-II (Korkman, Kirk & Kemp, 2007) was used to assess inhibition. This task is divided in two parts: Naming (where the child has to say the shape of each object displayed in the sheet) and Inhibition (naming each object with the opposite name, i.e., saying "square" when seeing a circle). The measurements recorded were the number of errors and the time spent for the execution of both tasks and these were combined in a scaled global score according to the manual's instructions. Working memory was assessed using the digit-span subtest of the WISC-V (Wechsler, 2014). In this, participants were asked to repeat strings of digits exactly as presented (forward condition) and in a reverse order (backward condition). The task was conducted according to the WISC Manual with no time limit. For both forward and backward conditions, total raw scores were recorded and transformed to scaled scores for analysis.

The Wisconsin Card Sorting Test (WCST) was used to evaluate cognitive flexibility. In this task, the child is required to find the correct classification principle of a card game by trial and error taking into account the examiner's feedback. To get a total score, we used the scoring method proposed by Laiacona *et al*. (2000) which captures, in a single measure, the number of categories completed, number of trials administered, percent conceptual level responses and total number of errors.

Diagnostic tests of linguistic and mathematical competence

To evaluate the key school competences we used mathematics and language (Catalan) standardized tests from the Education Department of the Catalan government. These tests are objective and homogeneous and provide a precise application and correction criteria. The test versions applied were chosen together with the participants' teachers to ensure that they were new for the students, bearing in mind that this test is usually administered to the 4th and 6th grades.

The language test of 3rd grade was based on a text with eight reading comprehension questions, while the 5th grade test consisted in a task of reading comprehension and a writing exercise in which the students were asked to write a short text. Each task (reading comprehension and writing) was scored from 0 to 10, following the correction instructions of the tests.

Furthermore, to ensure maximal objectivity in the qualification of the writing task, the exercise was reviewed by the original author and another researcher not involved in the study, and the inter-rater agreement was calculated using the Cohen's Kappa statistic (= 0.64).

The mathematics test, on the other hand, followed the same format for both grades. It consisted of five tasks based on real-life scenarios, each with a distinct style of exercise (multiple choice questions, chart interpretations, circle the correct drawing, etc.). Each test took 1 h to be completed and was graded on a scale of 0–10.

In Table 1 there is a summary of the constructs and instruments used in the study.

Procedure

Data collection was carried out during the 2018–2019 school year. Schools were informed about the aims of the study, and families were asked to sign an informed consent to allow their children participate. All the research followed the ethical principles of scientific research, and was approved by the Ethical and Biosecurity Research Committee of the authors' university.

The EI questionnaire and the school competences test were administered to all students in the mainstream classroom in two different sessions. The first one, which lasted 45 min, included the assessment of emotional intelligence with the BarOn inventory, while the second one, which took place 1 week later, was dedicated to testing the linguistic and mathematic competences with a standardized test and lasted 2 h.

The hands-on EF tasks were administered individually in a small and quiet room the following weeks. The order of administration of the testes were the same for all children: working memory task (Digit Span), inhibition task (subtest of Nepsy-II) and cognitive flexibility (WCST). Each session lasted around 25 min.

Data analyses

Data was analyzed using the SPSS 25 statistical program. Descriptive and correlational analyses were performed with the EI and EF scores and the marks of linguistic and mathematics competence tests to explore the relationships between these constructs. Multiple linear regressions analyses were also carried out to analyze the predictive capacity of each of the EI dimensions and EF for the scholastic competences. The different subscales of the BarOn inventory (interpersonal, intrapersonal, adaptability, and stress management) and the score of the three EF tasks (WM, inhibition and cognitive flexibility) were introduced as independent variables, and the marks of the tests as responding variables.

Table 1. *List of constructs and measures for the study*

Construct	Measure	Scoring
Emotional intelligence	BarOn emotional intelligence inventory – EQi:YV	Global IQ (M = 100, SD = 15)
Inhibition	Inhibition subtest of Nepsy-II	Combined score (errors/time) Range = 1–19 (scaled score)
Working memory	Digit span of WISC-V	Scaled score (M = 10; SD = 3) Range = 4–15
Cognitive flexibility	WCST	Global score (Combination of categories completed, administered trials, percent conceptual level responses and total number of errors). Range = 0–128
Academic achievement	Standardized diagnostic tests of the Catalan Government (language and mathematics)	Mark between 0–10.

RESULTS

Preliminary analyses

Prior to the correlation and regression analyses, data were screened for multivariate outliers. For this, the Mahalanobis distance was used across the eight cognitive variables. Seven multivariate outliers were identified ($p < 0.001$) and removed from subsequent analyses (Tabachnick & Fidell, 2007). Also, a post hoc power analyses was computed to ensure that the final sample size was sufficient to detect an adequate effect.

Descriptive statistics

Descriptive statistics for the EI measures, executive function tasks and students' school performance are provided in Table 2. The mean scores of EI were almost identical for each of the dimensions, except for stress management that was slightly lower. All measurements of EI and EFs were in the normal ability range according to the manuals. A one-factor ANOVA was performed to analyze gender differences and no significant results were found ($p > 0.05$).

The fact that the mean of the scores for linguistic and mathematic achievement was quite high (7 out of 10) can be explained for the test chosen, as it evaluates the basic competences, which is the minimum know ledge and skills required in each stage.

Correlations

Correlations of EI measurements, EF tasks and school scores are presented in Table 3. Scores of language and mathematics were highly correlated with each other, and both subjects were significantly associated with all EF tasks. The highest correlations were with the inhibition task, both for language ($r = 0.50$, $p < 0.001$) and mathematics ($r = 0.54$, $p < 0.001$).

Table 2. *Descriptive statistics for EI measures, EF tasks and school performance*

Measure	*M*	*SD*
Emotional intelligence		
Global IQ	102.21	13.93
Intrapersonal EI	102.58	14.34
Interpersonal EI	102.72	14.00
Adaptability EI	101.45	15.25
Stress management EI	99.37	14.27
Executive function		
Working memory	9.44	2.57
Inhibition	11.47	3.25
Cognitive flexibility	63.15	28.44
Academic achievement		
Language	7.50	2.38
Mathematics	7.37	2.03

Table 3. *Correlations between EI measures, EF tasks and achievement*

	Emotional intelligence					Executive functions		
	EI total	Intrapers. EI	Interpers. EI	Adaptab. EI	Stress M.	Working Mem.	Inhibition	Cognit. Flexib.
Language	0.188*	0.005	0.212**	0.213**	0.120	0.390**	0.504**	0.247**
Math	0.043	−0.138	0.071	0.173*	0.063	0.439**	0.535**	0.346**

Notes: Intrapers., intrapersonal; Interpers., interpersonal; Adaptab., adaptability; Stress M., stress management; Working Mem., working memory; Cognit.Flexib., cognitive flexibility.
*$p < 0.05$.
**$p < 0.01$.

Total EI was only significantly correlated with achievement in language ($r = 0.19$, $p = 0.013$) but not in mathematics. At the subscale level, only two of the dimensions of EI were significantly associated with achievement: adaptability and interpersonal EI. Adaptability was strongly associated with children's scores both in language ($r = 0.21$, $p = 0.005$) and mathematics ($r = 0.17$, $p = 0.023$), but Interpersonal EI was only significantly associated with language score ($r = 0.21$, $p = 0.005$).

Regression analysis

To consider whether the different dimensions of EI an EF were predictive subsequent achievement, we performed two sets of stepwise linear regressions analysis, one for language and one for mathematics. We controlled for age, grade and gender (checking there was no collinearity between them). For each of the analyses, language and mathematics scores were regressed on all the EI dimensions (intrapersonal, interpersonal, adaptability and stress management) and all the EF tasks (working memory, inhibition and cognitive flexibility).

Table 4 presents regressions analyses results for mathematics and language achievement (reported for the final regression model only). In the case of mathematics, adaptability and intrapersonal were the only significant EI predictors of mathematics score, together with the three EF measures ($F[5, 167] = 22.669$, $p < 0.001$), explaining the 38.9% of the variance. Inhibition was shown to be the most significant predictor for scores in mathematics, followed by working memory and cognitive flexibility, with standardized coefficients ranging from 0.18 to 0.40. In a second level, with smaller predictive power we found the intrapersonal EI dimension (significant in a negative way) and adaptability. Therefore, EFs predicted mathematics performance better than EI measurements.

Regarding language, a similar pattern of results was obtained, as the EFs were found to predict a large part of its execution. Interpersonal EI emerged as the only emotional intelligence predictor for its achievement, together with the EF of inhibition and working memory ($F[3, 167] = 26.036$, $p < 0.001$), with an R^2 of 0.306. Adaptability did not reach the threshold to become a significant predictor and neither did cognitive flexibility, both significant in the correlations. Again, inhibition and working memory were shown to be the most powerful predictors of language achievement with a beta of 0.41 and 0.20 respectively.

DISCUSSION

The present study explored the impact of both trait EI and EF on academic achievement in a group of primary school students. Results showed that executive functions were by far the stronger predictor of performance in language and mathematics, which is in line with previous studies (Baggetta & Alexander, 2016; Pascual, Moyano & Robres, 2019). However, we also found evidence that EI predicts academic achievement, which is also supported by empirical work (Mavroveli, Petrides, Sangareau & Furnham, 2009; Perera & DiGiacomo, 2013).

First, we will focus on the results of mathematics and then on those of language. In this sense, we observed that mathematic competence was largely predicted by inhibition, and to a lesser extent, by working memory and cognitive flexibility. These findings are similar to those previously reported in school-age

Table 4. *Multiple linear regressions between EI measures, EF tasks and achievement*

Variables	*B*	*SE*	β	*t*	Sig	*F*	Adj. R^2
Math							
Constant	2.873	1.164		2.468	0.015	22.669	0.389
Inhibition	0.247	0.041	0.397	6.029	0.000		
Working memory	0.146	0.054	0.184	2.694	0.008		
Cognitive flexibility	0.014	0.005	0.192	3.043	0.003		
EI-intrapersonal	−0.024	0.009	−.173	−2.678	0.008		
EI-adaptability	0.019	0.009	0.144	2.231	0.027		
Language							
Constant	−0.666	1.252		−0.532	0.595	26.036	0.306
Inhibition	0.301	0.050	0.413	5.989	0.000		
Working memory	0.190	0.065	0.204	2.949	0.004		
EI-interpersonal	0.028	0.011	0.168	2.609	0.010		

children (Bull & Scerif, 2001; Gathercole & Pickering, 2000) and demonstrate the consistency of the relationship between executive functions and mathematic competence.

Inhibition is considered crucial for the acquisition of new solution strategies, as well as for switching between already learned solution strategies (Lemaire & Siegler, 1995). In this particular case, inhibition may be involved in the suppression of incorrect strategies, such as using addition when subtraction is required, suppression of irrelevant information in a problem formulation, or suppression of an old activated schema when a new one needs to be set up for a specific task.

Working memory has shown to be also important for mathematics. For example, in this research, this component may has played a role to support the retention of problem information and direct retrieval of arithmetic facts from long-term memory. Working memory also helps to support the many simultaneous cognitive demands of processing and storage placed by mathematical computations (Gathercole & Pickering, 2000). In this sense, having good levels of working memory could have helped children to not forget intermediate results or make procedural errors.

Finally, cognitive flexibility is necessary when children switch between operations, strategies and quantity ranges in order to get a successful answer (Bull & Scerif, 2001). An example of this situation can be found in the alternation of arithmetic sub-solutions in multi-step problems, found in both tests administered.

In terms of EI, adaptability and intrapersonal (negatively) were the EI dimensions more related to math score. In this context, adaptability can be understood as the capacity of the students to manage new tasks or change in their mathematical knowledge. Therefore, modifying the way of approaching a problem, or down-regulating emotions when facing an unresolved problem, are just some examples of how adaptability may be related to mathematics performance.

We found a significant negative correlation between the scores on the Intrapersonal EI component and the students' scores in the mathematics task. This result is line with those of Brouzos *et al.* (2014) and Hogan, Parker, Wiener, Watters, Wood and Oke (2010). Even though it may be related to the developmental course of this EI component, as interpersonal skills have a pronounced improvement in the pre-adult years (Labouvie-Vief, DeVoe & Bulka, 1989), further investigation is needed to better explain the negative relationship found.

Performance in language was mainly predicted by inhibition and working memory, which fits well with previous research (Chung & McBride-Chang, 2011; Nouwens, Groen, Kleemans & Verhoeven, 2021). Proper reading comprehension requires storage and processing of information while inhibiting off-goal information and updating memory content information. Therefore, in this study, in which the reading exercise had an important weigh in the final linguistic competence score, working memory skills emerged as crucial.

Inhibitory control appeared to be very important too for linguistic competence. Reading involves choosing important information to build a coherent representation of the meaning of the text. If inhibitory skills do not work well, irrelevant information may damage the maintenance of significant information and thus its integration and comprehension of the text. Hence, it is supposed that students with good levels of inhibition were able to answer the reading comprehension questions properly because they focused their attention and selected the important parts of the text while inhibiting others that were not relevant to the question. In addition, reasoning questions (those which does not have the answers explicitly in the text) were also present in the test, and for responding them inhibitory skills are key (Van der Sluis, de Jong & Van der Leij, 2007).

The contribution of inhibition to academic achievement, both in language and mathematics, was central in the sample, suggesting it is an essential skill for learning in general (Clark, Pritchard & Woodward, 2010; Espy *et al.*, 2004; Introzzi, Canet, Aydmune & Stelzer, 2016). In this sense, Miyake *et al.* (2000) hypothesized that inhibition may exert a unifying role in executive functions, as all of them involve some inhibitory processes to function properly.

The fact that cognitive flexibility did not appear as a predictor of linguistic competence, while all the other EFs analyzed did, was somewhat unexpected. However, these results are in line with those of St. Clair-Thompson and Gathercole (2006), who also failed to identify cognitive flexibility as a key factor for language, and with those of Van der Sluis *et al.* (2007), who even found a negative relationship between cognitive flexibility and reading. Our findings could be due to the developmental course of this specific EF, as this EF component is thought to develop later resulting from improvements in working memory and inhibition (Zelazo, Müller, Frye *et al.*, 2003). In these sense, cognitive flexibility may have comparatively less generalized relations with achievement in primary grades (Morgan, Farkas, Wang, Hillemeier, Oh & Maczuga, 2019) and may differentially contribute to some but not other types of achievement (Clements, Sarama & Germeroth, 2016).

In our sample, the only EI factor related with the language score was the interpersonal component. Students with high scores in the interpersonal dimension are usually good listeners and communicators, and it is easy for them to be aware of others' feelings when interacting with them. For this reason, when doing the reading exercise, these students most probably do not have any problems to put themselves in the shoes of the characters and answer correctly the questions about their feelings or emotions (despite the answer could not be found directly in the text). In addition, it could be helpful for the writing task when choosing the right register and style. Finally, a student with good interpersonal skills is also more engaged in satisfying social relationships, which in turn, might facilitate a good classroom environment for learning.

Although in our sample, the only EI dimension linked with the language score was the interpersonal component, previous studies with older students found that adaptability was the unique predictor of their achievement (Parker *et al.*, 2004). A possible explanation for this is that the interpersonal processes of EI are more pronounced in the first years of schooling, when teachers use collaborative strategies (such as group projects, corners or role-plays), whereas in later stages, the educational context is more individual and autonomous, and other EI factors such as stress management or adaptability become more relevant. If this interpretation is correct, primary schools should be aware of the EI demands that are involved in the language tasks they pose on their children, in order to support students with low interpersonal

skills. Alternatively, this discrepancy between our study and Parker *et al.*'s may be due to differences in the school learning context or to the measures of academic achievement used in each study.

In sum, the present research analyzed in depth the relationship between EFs, EI and academic achievement in primary school, finding that executive functions are better predictors of school competences compared to EI. One of the main objectives of the study was to identify the specific EF and EI dimensions most related to school performance. In this sense, we observed that inhibition and working memory were the executive functions more associated with achievement in both of the analyzed subjects (language and mathematics). In terms of EI, adaptability emerged as the dimension most linked to academic achievement in general, together with the interpersonal factor for language and the intrapersonal for math (in a negative way). In conclusion, executive functions, and especially inhibition, seem to be generic to learning rather than specific to attainment in one particular domain, whereas, EI (and each component in particular) might have a specific contribution to the different areas of the curricula.

Limitations and futures studies

Despite our interesting findings, we have to acknowledge two main limitations in the present work: first, the sample size; and second, the measurements used for the assessment of academic performance. Concerning the sample size, the number of subjects available did not allow further scrutiny (i.e., gender specific or partial correlations controlling for age, structural equation models, etc.). However, our sample size is in line with similar studies of this type (Brouzos *et al.*, 2014; Mavroveli, Petrides, Sangareau & Furnham, 2009) and is sufficient for the main purposes of this research. With respect to measurements, multiple indicators of school achievement could have been assessed to better define academic performance. The one used in this study is a test of basic competences that assesses academic achievement in a concrete point of time and thus, contextual variables beyond children's control could have affected the results (having a bad day, a mental block, etc.). Also, each EF could have been assessed with more than one task, to make the assessment more comprehensive. Future research should elucidate better the association of EI and EFs with academic achievement by exploring other personal and contextual factors, such as gender, intelligence, social context, support, etc. This would help better explain the variability found in such a multicomponent construct.

In addition, it would be extremely valuable to extend the current findings of the contribution of executive functions and emotional intelligence to learning in a larger-scale longitudinal study, tracking a sample of children across all school stages. This would contribute to obtain a more detailed and exhaustive analysis of the changing contributions of EI and EFs to academic achievement.

Educational implications

The above-mentioned results have implications for schools managers and classroom practice. First, it has been shown that good emotional intelligence and good levels of executive functioning provide children with an advantage for learning in the school environment. Knowing this, there is a need to move to a more comprehensive education in schools that addresses the promotion of not only academic but also personal, social and emotional competences (Corcoran, Kim & Xie, 2018). For this, the application of Social and Emotional Learning (SEL) in the curricula would be an adequate strategy, but first, teachers must be trained in good teaching practices that not only focus on instruction content but also guide them in the emotional domain (Oberle & Schonert-Reichl, 2016).

At the same time, it is important to make teachers aware of the importance of executive functions in academic development. Only in this way, would they be able to translate the extant knowledge into meaningful educational experiences and embed classroom practices that foster EF development. Nowadays there is a growing body of programs with promising results intended to enhance children's executive skills in the school context, such as PATHS curriculum and Tools of the Mind, which have obtained great results (Blair & Razza, 2007). Taking them as a model would be an interesting way to start.

The results also have implications for school and educational psychologists. Knowing the EI profile of students can help them to examine their strengths and weaknesses and also, and more importantly, to identify children in need of intervention. This would help to create a solid affective basis, which would serve as an important supportive prerequisite for academic achievement.

This study contributes to the growing literature of emotional and cognitive processes by suggesting that individuals with good executive functions and high scores in specific EI components have advantages in school settings and thus, EI and EFs should be consciously and constructively developed in young children.

CONCLUSION

The present study provides evidence for the relationship between specific dimensions of EI and EFs with academic achievement. The results showed that EFs have more power than EI for explaining school performance, with inhibition and working memory the stronger predictors. In terms of EI, adaptability and the intrapersonal dimension (this last one in a negative way) were crucial for the achievement in math, while the interpersonal factor was the most important factor for language.

The present results suggest that having good EFs and certain emotional skills is important for academic performance. Thus, schools should foster these factors among their students to promote their well-being and the achievement of all their potential.

FUNDING INFORMATION

This work was supported by the Generalitat de Catalunya (AGAUR), grant number 2020FI_B200106 and by the Ministerio de Educación y Cultura, grant number PSI2015-69419-R.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author

REFERENCES

Agostino, A., Johnson, J. & Pascual-Leone, J. (2010). Executive functions underlying multiplicative reasoning: Problem type matters. *Journal of Experimental Child Psychology*, *105*, 286–305.

Ahmed, S.F., Tang, S., Waters, N.E. & Davis-Kean, P. (2019). Executive function and academic achievement: Longitudinal relations from early childhood to adolescence. *Journal of Educational Psychology*, *111*, 446–458.

Baggetta, P. & Alexander, P.A. (2016). Conceptualization and operationalization of executive function. *Mind, Brain, and Education*, *10*, 10–33.

Bar-On, R. & Parker, J.D.A. (2000). *BarOn emotional quotient inventory: Youth version*. Toronto: MHS.

Blair, C. & Razza, R.P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*, 647–663.

Brouzos, A., Misailidi, P. & Hadjimattheou, A. (2014). Associations between emotional intelligence, socio-emotional adjustment, and academic achievement in childhood. *Canadian Journal of School Psychology*, *29*, 83–99.

Bull, R. & Scerif, G. (2001). Executive functioning as a predictor of children's mathematics ability: Inhibition, switching, and working memory. *Developmental Neuropsychology*, *19*, 273–293.

Cartwright, K.B., Marshall, T.R., Dandy, K.L. & Isaac, M.C. (2010). The development of graphophonological-semantic cognitive flexibility and its contribution to reading comprehension in beginning readers. *Journal of Cognition and Development*, *11*(1), 61–85.

Chung, K.K. & McBride-Chang, C. (2011). Executive functioning skills uniquely predict Chinese word Reading. *Journal of Educational Psychology*, *103*, 909–921.

Clark, C.A., Pritchard, V.E. & Woodward, L.J. (2010). Preschool executive functioning abilities predict early mathematics achievement. *Developmental Psychology*, *46*, 1176–1191.

Clements, D.H., Sarama, J. & Germeroth, C. (2016). Learning executive functionand early mathematics: Directions of causal relations. *Early Childhood Research Quarterly*, *36*, 79–90.

Corcoran, R.P., Cheung, A.C., Kim, E. & Xie, C. (2018). Effective universal school-based social and emotional learning programs for improving academic achievement: A systematic review and meta-analysis of 50 years of research. *Educational Research Review*, *25*, 56–72.

De Beni, R. & Palladino, P. (2000). Intrusion errors in working memory tasks: Are they related to Reading comprehension ability? *Learning and Individual Differences*, *12*, 131–143.

Diamond, A., Kirkham, N. & Amso, D. (2002). Conditions under which young children can hold two rules in mind and inhibit a prepotent response. *Developmental Psychology*, *38*(3), 352.

Droppert, K., Downey, L., Lomas, J., Bunnett, E.R., Simmons, N., Wheaton, A. *et al.* (2019). Differentiating the contributions of emotional intelligence and resilience on adolescent male scholastic performance. *Personality and Individual Differences*, *145*, 75–81.

Eastabrook, J.M., Duncan, A. & Eldridge, B. (2005). *Academic success in elementary school: Does EI matter? [Paper presentation]*. Annual Meeting of the Canadian Psychological Association, Montreal, Quebec, Canada. https://cpa.ca/cpasite/UserFiles/Documents/aboutcpa/annual_reports/Annual_Report_2005.pdf

Espy, K.A., McDiarmid, M.M., Cwik, M.F., Stalets, M.M., Hamby, A. & Senn, T.E. (2004). The contribution of executive functions to emergent mathematic skills in preschool children. *Developmental Neuropsychology*, *26*, 465–486.

Espy, K.A., Sheffield, T.D., Wiebe, S.A., Clark, C.A. & Moehr, M.J. (2011). Executive control and dimensions of problem behaviors in preschool children. *Journal of Child Psychology and Psychiatry*, *52*(1), 33–46.

Foy, J.G. & Mann, V.A. (2013). Executive function and early Reading skills. *Reading and Writing*, *26*, 453–472.

Gashaj, V., Oberer, N., Mast, F.W. & Roebers, C.M. (2019). Individual differences in basic numerical skills: The role of executive functions and motor skills. *Journal of Experimental Child Psychology*, *182*, 187–195.

Gathercole, S.E. & Pickering, S.J. (2000). Working memory deficits in children with low achievements in the national curriculum at 7 years of age. *British Journal of Educational Psychology*, *70*, 177–194.

González Yubero, S., Palomera Martín, R. & Lázaro Visa, S. (2019). Trait and ability emotional intelligence as predictors of alcohol consumption in adolescents. *Psicothema*, *31*, 292–297.

Hogan, M.J., Parker, J., Wiener, J., Watters, C., Wood, L.M. & Oke, A. (2010). Academic success in adolescence: Relationships among verbal IQ, social support and emotional intelligence. *Australian Journal of Psychology*, *62*, 30–41.

Introzzi, I., Canet, L., Aydmune, Y. & Stelzer, F. (2016). Theoretical perspectives and empirical evidence on inhibition. *Revista Colombiana de Psicología*, *25*, 351–368.

Korkman, M., Kirk, U. & Kemp, S. (2007). *NEPSY II: Clinical and interpretive manual*. Chicago, IL: Harcourt Assessment, PsychCorp.

Labouvie-Vief, G., DeVoe, M. & Bulka, D. (1989). Speaking about feelings: Concepts of emotion across the life span. *Psychology and Aging*, *4*, 425–437.

Laiacona, M., Inzaghi, M.G., De Tanti, A. & Capitani, E. (2000). Wisconsin card sorting test: a new global score, with Italian norms, and its relationship with the Weigl sorting test. *Neurological Sciences*, *21*, 279–291.

Le Hoang, H.T. & Grégoire, J. (2021). Understanding emotion awareness and emotion vocabulary in early primary school Vietnamese children: Quantitative and qualitative analyses. *PsyCh Journal*, *10*, 47–61.

Lee, K., Ee Lynn, N.G. & Swee Fong, N.G. (2009). The contributions of working memory and executive functioning to problem representation and solution generation in algebraic word problems. *Journal of Educational Psychology*, *101*, 373–387.

Lemaire, P. & Siegler, R.S. (1995). Four aspects of strategic change: Contributions to children's learning of multiplication. *Journal of Experimental Psychology: General*, *124*, 83–97.

MacCann, C., Jiang, Y., Brown, L.E., Double, K.S., Bucich, M. & Minbashian, A. (2020). Emotional intelligence predicts academic performance: A meta-analysis. *Psychological Bulletin*, *146*, 150–186.

Magalhães, S., Carneiro, L., Limpo, T. & Filipe, M. (2020). Executive functions predict literacy and mathematics achievements: The unique contribution of cognitive flexibility in grades 2, 4, and 6. *Child Neuropsychology*, *26*, 934–952.

Matešić, K. (2015). The relationship between cognitive and emotional intelligence and high school academic achievement. *Collegium Antropologicum*, *39*, 371–375.

Mavroveli, S., Petrides, K.V., Sangareau, Y. & Furnham, A. (2009). Exploring the relationships between trait emotional intelligence and objective socio-emotional outcomes in childhood. *British Journal of Educational Psychology*, *79*, 259–272.

McCoy, C.L. & Masters, J.C. (1985). The development of children's strategies for the social control of emotion. *Child Development*, *56*, 1214–1222.

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*, 49–100.

Morgan, P.L., Farkas, G., Wang, Y., Hillemeier, M.M., Oh, Y. & Maczuga, S. (2019). Executive function deficits in kindergarten predict repeated academic difficulties across elementary school. *Early Childhood Research Quarterly*, *46*, 20–32.

Nesbitt, K.T., Farran, D.C. & Fuhs, M.W. (2015). Executive function skills and academic achievement gains in prekindergarten: Contributions of learning-related behaviors. *Developmental Psychology*, *51*, 865–878.

Nouwens, S., Groen, M.A., Kleemans, T. & Verhoeven, L. (2021). How executive functions contribute to reading comprehension. *British Journal of Educational Psychology*, *91*, 169–192.

Oberle, E. & Schonert-Reichl, K.A. (2016). Stress contagion in the classroom? The link between classroom teacher burnout and morning cortisol in elementary school students. *Social Science & Medicine*, *159*, 30–37.

Parker, J.D., Creque, R.E., Sr., Barnhart, D.L., Harris, J.L., Majeski, S.A., Wood, L.M. *et al*. (2004). Academic achievement in high school: Does emotional intelligence matter? *Personality and Individual Differences*, *37*, 1321–1330.

Pascual, A., Moyano, N. & Robres, A. (2019). The relationship between executive functions and academic performance in primary education: Review and meta-analysis. *Frontiers in Psychology*, *10*, 1582. https://doi.org/10.3389/fpsyg.2019.01582.

Passolunghi, M.C. & Siegel, L.S. (2001). Short-term memory, working memory, and inhibitory control in children with difficulties in arithmetic problem solving. *Journal of Experimental Child Psychology*, *80*, 44–57.

Perera, H.N. & DiGiacomo, M. (2013). The relationship of trait emotional intelligence with academic performance: A meta-analytic review. *Learning and Individual Differences*, *28*, 20–33.

Petrides, K.V., Frederickson, N. & Furnham, A. (2004). The role of trait emotional intelligence in academic performance and deviant behavior at school. *Personality and Individual Differences*, *36*(2), 277–293.

Petrides, K.V., Sanchez-Ruiz, M.J., Siegling, A.B., Saklofske, D.H. & Mavroveli, S. (2018). Emotional intelligence as personality: Measurement and role of trait emotional intelligence in educational contexts. *Emotional intelligence in education: Integrating research with practice* (pp. 49–81). Cham: Springer.

Pulido-Acosta, F. & Herrera-Clavero, F. (2018). Prediciendo el Rendimiento Académico Infantil a través de la Inteligencia Emocional. *Educational Psychology*, *25*, 23–30.

Qualter, P., Whiteley, H.E., Hutchinson, J.M. & Pope, D.J. (2007). Supporting the development of emotional intelligence competencies to ease the transition from primary to high school. *Educational Psychology in Practice*, *23*, 79–95.

Romine, C.B. & Reynolds, C.R. (2005). A model of the development of frontal lobe functioning: Findings from a meta-analysis. *Applied Neuropsychology*, *12*, 190–201.

Schlegel, K., Palese, T., Mast, M.S., Rammsayer, T.H., Hall, J.A. & Murphy, N.A. (2020). A meta-analysis of the relationship between emotion recognition ability and intelligence. *Cognition and Emotion*, *34*, 329–351.

Sesma, H.W., Mahone, E.M., Levine, T., Eason, S.H. & Cutting, L.E. (2009). The contribution of executive skills to reading comprehension. *Child Neuropsychology*, *15*, 232–246.

St. Clair-Thompson, H.L. & Gathercole, S.E. (2006). Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. *Quarterly Journal of Experimental Psychology*, *59*, 745–759.

Tabachnick, B.G. & Fidell, L.S. (2007). *Experimental designs using ANOVA* (Vol. *724*). Belmont, CA: Thomson/Brooks/Cole.

Van der Sluis, S., de Jong, P.F. & Van der Leij, A. (2007). Executive functioning in children, and its relations with reasoning, reading, and arithmetic. *Intelligence*, *35*, 427–449.

Wechsler, D. (2014). *WISC-V: Wechsler intelligence scale for children*. San Antonio, TX: Pearson Education.

Zelazo, P.D., Müller, U., Frye, D., Marcovitch, S., Argitis, G., Boseovski, J. *et al*. (2003). The development of executive function in early childhood. *Monographs of the Society for Research in Child Development*, *68*(3), vii–137.

Zhoc, K.C., King, R.B., Chung, T.S. & Chen, J. (2020). Emotionally intelligent students are more engaged and successful: Examining the role of emotional intelligence in higher education. *European Journal of Psychology of Education*, *35*, 839–863.

Received 10 March 2022, Revised 14 November 2022, accepted 24 January 2023