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Original

Involvement of executive functions, emotional intelligence, and study habits in mathematical problem-solving and calculation in elementary school☆

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ABSTRACT

As mathematics is the most difficult subject for students from an early age, it is necessary to understand the underlying processes. Thus, the aim of this study was to analyze the relationship between calculation and mathematical problem-solving (MPR) skills with Executive Functions (EF), Emotional Intelligence (EI), and Study Habits and Techniques (SHT) in children aged 9-12 years. The study was carried out with 70 students (40 girls) from five schools in the Autonomous Community of the Basque Country of Spain. The results showed that MPR was significantly related to EF, SHT, and EI, while calculation was only related to EF and SHT, all this controlling the effect of IQ. Furthermore, MPR has correlated with a greater number of EF, EI, and SHT subscales than calculation. Along with this, significant differences have been observed in EF and EI depending on the level of performance in MPR, while in calculation the significant differences have been found in EF and SHT. Therefore, different neuropsychological processes underlie each mathematical skill, which implies the need for differential intervention with each of them. All of this through programs that encourage the mathematical learning of all students indiscriminately or that promote the development of mathematical skills according to the specific difficulty of the student.

Implicación de las funciones ejecutivas, la inteligencia emocional y los hábitos y técnicas de estudio en la resolución de problemas matemáticos y el cálculo en la escuela primaria

Palabras clave:
matemáticas
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RESUMEN

Dado que matemáticas es la asignatura más difícil para el alumnado desde edades tempranas, es necesario comprender los procesos subyacentes. Así, con el presente estudio se ha pretendido analizar la relación entre las habilidades de cálculo y resolución de problemas matemáticos (RPM) con las funciones ejecutivas (FE), la inteligencia emocional (IE) y los hábitos y técnicas de estudio (HTE) en estudiantes de 9-12 años. El estudio se ha llevado a cabo con 70 estudiantes (40 niñas) de cinco escuelas de la Comunidad Autónoma del País Vasco de España. Los resultados han mostrado que la RPM se relaciona significativamente con las FE, la IE y los HTE, mientras que el cálculo sólo ha correlacionado con las FE y los HTE, todo ello controlando el efecto del CI. Además, la RPM ha correlacionado con un mayor número de subescalas de las EF, la EI y los HTE que el cálculo. Junto a ello, se han observado diferencias significativas en las EF y la EI en función del nivel de rendimiento en RPM, mientras que en cálculo se han encontrado diferencias significativas en las EF y los HTE. Por tanto, diferentes procesos neuropsicológicos subyacen a cada habilidad matemática, lo que implica la necesidad de una intervención diferencial con cada una de ellas.

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Todo ello a través de programas que fomenten el aprendizaje matemático de todo el alumnado indistintamente o que promuevan el desarrollo de las habilidades matemáticas en función de la dificultad específica del estudiante.

Introduction

Mathematical learning is important for academic, professional, and social purposes (Rodríguez et al., 2021), but it is also one of the school subjects that entails the greatest difficulties for students (García et al., 2007), and these are usually detected late (Rodríguez et al., 2021). Mathematics is a complex and hierarchical learning (Rodríguez et al., 2021) and, in elementary school, calculation and problem-solving are central skills to mathematical learning (Fuchs et al., 2008). In calculation, the problem is prepared for its resolution and involves counting, arithmetic combinations, and retrieving numerical facts, while regroupings are performed and position values are attended to (Fuchs et al., 2008; Peng et al., 2016). In contrast, mathematical problem-solving (MPR) is a more complex cognitive activity that pursues a goal without immediate response (Gastañaduy et al., 2021) and that requires linguistic information processing to understand and structure the problem, understand and represent the underlying arithmetic operation, and resume the strategies of calculation (Peng et al., 2016).

Mathematical cognition involves coordinated functionality between multiple brain areas (Menon, 2016), but the relationship between mathematical ability and brain activity seems to vary depending on the difficulty of the task, how the information is presented, the strategy used, and the subject's mathematical competence and age (Kaufmann et al., 2011; Menon, 2016). Thus, mathematical performance is related to several factors, among which early mathematical skills (Mulder et al., 2017), general intelligence (Ramírez-Benítez et al., 2016), and other higher cognitive processes such as executive functions (EF) stand out (Cragg & Gilmore, 2014; Medrano & Prather, 2023). Other authors also highlight the incidence of aspects such as motivation, emotions, and study habits (Agnoli et al., 2012; Capdevila Seder & Bellmunt Villalonga, 2016). In fact, from a neuroeducational perspective, it is being shown that all these cognitive and non-cognitive variables are relevant to learning processes and school performance (Quílez-Robres et al., 2021), but it is yet to be determined which specific skills underlie each academic ability.

EF are a set of essential capabilities for behavior and cognition, since they transform thoughts into plans, decisions and actions, to achieve a better adaptation to the environment (Portellano et al., 2011). Several authors highlight the importance of executive domains such as Inhibition, Working Memory, and Flexibility for students' mathematical performance as of early stages (Fuhs et al., 2016; Medrano & Prather, 2023; Mulder et al., 2017; Ribner et al., 2017). However, consistent conclusions regarding the differential role of the executive components in the development of each mathematical skill, such as MPR and calculation, are lacking, which could be due to the methodological differences and diversity in the age of the samples used (Filippetti & Richaud, 2017; Fuhs et al., 2016; Jacob & Parkinson, 2015; Medrano & Prather, 2023).

Emotional intelligence (EI) is another factor that seems to influence students' academic and mathematical development. It involves the interrelation between emotional, social and cognitive competencies in order to enable intelligent and healthy behavior (Bar-On & Parker, 2018). There are different theoretical models of emotional intelligence (Kanesan & Fauzan, 2019): skill-based models that view it as a mental ability focused on emotional processing (Salovey & Mayer, 1990); and mixed models that add personality traits to emotional intelligence (Bar-On & Parker, 2018). The different models converge in the search for the interpretation and management of our own and other people's emotions in order to tend towards adaptive behavior (Sotelo-Martín et al., 2019). Several authors point out that high levels of EI are associated with better academic development (Hanin & Van Nieuwenhoven, 2016), but most studies in this field have been conducted with adolescent or university students (Costa & Faria, 2015; Justicia-Galiano et al., 2015). However, Agnoli et al. (2012) observed that EI is positively related to math scores in children aged 8-11 years, but there is a lack of evidence on the involvement of EI in MPR and calculation performance. The evidence at this school stage is still scarce and contradictory, which could be due to the immature development of emotional competencies during that school period (Billings et al., 2014; Hansenne & Legrand, 2012).

Another variable that is presented as an important factor in academic and mathematical performance is Study Habits and Techniques (SHT) (Capdevila Seder & Bellmunt Villalonga, 2016; García et al., 2007; Quílez-Robres et al., 2021). SHT are a set of strategies or systematic learning trends that allow the development of autonomy in the processes of acquisition of new learning while favoring more meaningful and efficient learnings (Álvarez & Fernández, 2015). Study skills require strategic and metacognitive procedures that are implemented during the learning process (Venet & Carbo, 2017) while study habits represent regular practices and set of routines that the student carries out to achieve learning (Rabia et al., 2017). Most of the studies have focused on adolescent or university students (García et al., 2007; Hsieh, 2023), although a study conducted with students of elementary school also found a positive relationship between SHT and mathematics achievement (Tok, 2013). However, there is a lack of evidence about the involvement of SHT in the mathematical performance and their implication in MPR and calculation development of students in different elementary school grades.

The conclusions of the aforementioned studies highlight the existing controversies about the multifactorial processes that underlie mathematical performance in elementary school. Much research in this area has focused on the importance of contextual, educational and domain-specific skill factors for mathematical performance, but more research is needed on the role of domain-general processes (Medrano & Prather, 2023). Thus, this study proposed the general objective of analyzing the relationship between calculation and MPR skills with EF, EI, and SHT in children aged 9-12 years. The following specific objectives were established: (1) to study the relationship between the target variables (EF, EI, and SHT) and mathematical skills (MPR and calculation) while controlling for the effect of the Intelligence Quotient (IQ); (2) to analyze the relationship between each subscale of target variables (EF, EI, and SHT) and mathematical skills (MPR and calculation); and (3) to study the differences in the scores of EF, EI, and SHT according to the level of performance in calculation and MPR (low-medium or medium-high).

Method

Participants

The study was carried out with 70 students ($n = 40$, female 57.1%; $n = 30$, male 42.9%) of elementary school (4th to 6th grade) aged 9-12 years old ($M = 9.76$, $SD = .89$) from five schools (with linguistic model B or D) in the Autonomous Community of the Basque Country (ACBC) of Spain. To homogenize the characteristics of the schools, the following inclusion criteria were established for the villages where the school are located based on data provided by the Basque Institute of Statistics [EUSTAT] (2016): family income equal to or higher than the average of the ACBC, level of higher education equal to or higher than the average of the ACBC, and use of the Basque language equal to or higher than the average of the ACBC. The families interested signed the informed consent form and completed a questionnaire about the child's development and environment. The children who met the following inclusion criteria were then included in the sample: presenting the signed consent, having an IQ equal to or greater than 80, not having any mental disorder according to the Diagnostic and Statistical Manual of Mental Disorder-5th (American Psychiatric Association, 2013), and be bilingual in Basque and Spanish. The majority of the sample belonged to the high socioeconomic level (60%), followed by the medium level (21.4%) and the medium-high level (18.6%).

Instruments

Evaluación Neuropsicológica de las Funciones Ejecutivas en Niños (ENFEN) (Portellano et al., 2011). This test evaluates the maturative and cognitive level in tasks associated with the performance of EF in children aged 6-12 years. It consists of six subtests: *phonological fluency, semantic fluency, sustained attention, cognitive flexibility, planning*, and *inhibition*. It is applied individually and the scores are given in decatypes with the following descriptive categories: 1-2 *very low*, 3 *low*, 4 *medium-low*, 5-6 *medium*, 7 *medium-high*, 8 *high*, and 9-10 *very high*. Regarding the statistical support of the test, in the case of the present study, the internal consistency index was calculated with respect to reliability using Jamovi v.2.3.26 (The Jamovi Project, 2022): Cronbach's Alpha = 0.588; McDonald's $\omega = 0.617$.

Inventario de Inteligencia Emocional de BarOn: versión para jóvenes (7-18 años) (Bar-On & Parker, 2018). This self-report questionnaire evaluates EI and its components (*intrapersonal, interpersonal, adaptability, stress management*, and *general mood*). It can be applied individually or collectively (in this study, it was applied individually). The application and correction were carried out online through the Tea Corrige platform, providing an index for each dimension and a general index of EI (standard score with an average of 100 and standard deviation of 15). The ordinal reliability coefficients have been calculated for each component of the questionnaire with Jamovi v.2.3.26 (The Jamovi Project, 2022): *intrapersonal* (Alpha = 0.941; Guttman = 0.957; Omega = 0.975; Theta = 0.923); *interpersonal* (Alpha = 0.936; Guttman = 0.963; Omega = 0.956; Theta = 0.909); *adaptability* (Alpha = 0.905; Guttman = 0. 959; Omega = 0.943; Theta = 0.874); *stress management* (Alpha = 0.898; Guttman = 0.956; Omega = 0.939; Theta = 0.773); and *general mood* (Alpha = 0.966; Guttman = 0.971; Omega = 0. 978; Theta = 0.956).

Cuestionario de Hábitos y Técnicas de Estudio (CSHT) (Álvarez & Fernández, 2015). This self-report questionnaire evaluates seven scales associated with SHT: *general attitude towards study, place of study, student's physical fitness, work plan, study techniques, exams and exercises*, and *works*. Along with this, it provides an overall score for SHT. The application and correction were done online through the Tea Corrige platform, and scores are given in percentiles. As the questionnaire is corrected on the basis of hits and misses in contrast to a template, the specific case of Alpha with the Kuder-Richardson coefficient (KR20) has been calculated with Jamovi v.2.3.26 (The Jamovi Project, 2022): *general attitude towards study* (0.794); *place of study* (0.762); *student's physical fitness* (0.617); *work plan* (0.668); *study techniques* (0.568); *exams and exercises* (0.696); and *works* (0.359).

Batería de Actividades Mentales Diferenciales y Generales (BADyG) (Yuste et al., 2019; Yuste & Yuste, 2011). This battery measures the mental abilities and competencies of students in 3rd and 4th grade (BADyG E2) and 5th and 6th grade (BADyG E3) of elementary school. It consists of six basic and three complementary tests from which indicators are obtained, grouped into different factors (*verbal, numerical, visuospatial, logical reasoning*, and *general intelligence*). For the present study, as only mathematical skills were of interest, only the two basic tasks (calculation and MPR) that contribute to the generation of the numerical factor were used. This instrument can be applied either individually or collectively (in this case, it was carried out in both ways depending on the possibilities of the school) and the answers are corrected by checking the correct answers on a template, obtaining standardized scores in percentiles. The ω of McDonald has been calculated with Jamovi v.2.3.26 (The Jamovi Project, 2022): MPR (0.902) and calculation (0.858).

Test breve de Inteligencia de Kaufman (K-BIT) (Cordero-Pando & Calonge-Romano, 2011). This measures verbal and non-verbal intelligence between the ages of 4-90 years through individual application tasks. It consists of two parts: *matrixes* and *vocabulary* (composed of two subtests: *expressive vocabulary* and *definitions*). It provides standard scores for each part and an overall score of composite IQ (standard score with an average of 100 and standard deviation of 15). The ω of McDonald has been calculated with Jamovi v.2.3.26 (The Jamovi Project, 2022): *matrixes* (0.819), *expressive vocabulary* (0.604) and *definitions* (0.743).

Procedure

Initially, the project was approved by the ethics committee with the IP code: 015/20. After contacting with the schools that met the inclusion criteria ($n = 58$), five of them agreed to participate in the study. The families interested in participating then signed the informed consent form and completed the questionnaire about the child's biographical and environmental data. On that basis, the assessment instruments were applied to those children who met the inclusion criteria. In the first evaluation session, the K-BIT (approximate duration 30 minutes) and the ENFEN (approximate duration 20 minutes) were applied, and in the second session, the BADYG (approximate duration 25 minutes), all of them in person. The Bar-On (approximate duration 20-25 minutes) and CSHT (approximate duration 20 minutes) questionnaires were applied online through the Tea Corrige platform. The face-to-face evaluation sessions were held in a space free of distractions in each school and for the online application of the questionnaires, since the evaluator could not be present in person with the child, the following guidelines were provided to the families to avoid possible influences or distractions from family members: the child had to complete questionnaires in a space free of distractions with an adult available to clarify any doubts, although the child had to be alone when completing the questionnaire.

Data analysis

Descriptive analyses and non-parametric tests have been applied, due to the fact that some variables have not shown a normal distribution. Thus, for the Objective 1, Spearman partial correlation coefficient was calculated to explore the relationships

Table 1
Descriptive data of the study variables

	Mean	*SD*	Min.	Max.	95% CI
Math Skills (Pc)	56.47	27.02	1	98.50	[50.01 – 62.90]
MPR	55.73	27.53	1	99	[49.16 – 62.29]
Calculation	57.19	32.34	1	99	[49.48 – 64.90]
Executive Function (Decatype)	4.87	.97	2.67	7.50	[4.64 – 5.11]
Phonological fluency	3.41	1.88	1	8	[2.97 – 3.86]
Semantic fluency	4.74	1.68	1	9	[4.74 – 4.34]
Sustained attention	5.37	1.63	2	9	[4.98 – 5.76]
Cognitive flexibility	5.27	1.58	1	9	[4.90 – 5.65]
Planning	5.29	1.44	1	9	[4.94 – 5.63]
Inhibition	5.16	1.97	1	10	[4.69 – 5.63]
Emotional Intelligence (SS)	96.81	17.86	57	136	[92.56 – 101.07]
Intrapersonal	96.49	19.03	67	139	[91.95, 101.02]
Interpersonal	96.30	18.12	53	128	[91.98, 100.62]
Adaptability	94.63	15.58	68	134	[90.91, 98.34]
Stress management	103.56	12.66	63	130	[100.54 – 106.58]
General mood	94.39	19.92	47	124	[89.64 – 99.13]
Study Habits and Techniques (Pc)	51.52	22.14	2.57	93	[46.24 – 56.80]
Attitude towards study	55.13	29.98	3	99	[47.98 – 62.28]
Place of Study	48.37	32.61	1	99	[40.60 – 56.15]
Student's physical fitness	64.24	28.76	3	99	[57.39 – 71.10]
Work plan	44.44	28.92	3	92	[37.55 – 51.34]
Study techniques	39.56	28.15	1	99	[32.85 – 46.27]
Exams and exercises	55.41	33.57	1	99	[47.41 – 63.42]
Works	53.46	29.19	1	99	[46.50 – 60.42]
Intelligence Quotient (SS)	95.47	8.48	85	117	[93.45 – 97.49]

Note. *N* = 70; Min. = Minimum; Max. = Maximum; Pc = Percentile; SS = Standardized Score; MRP = Mathematical Problem-Solving.

between the study variables (EF, EI, and SHT) and mathematical skills (MPR and calculation) while controlling for the effect of the IQ. For Objective 2, the Spearman correlation has been applied to analyze the relationship between the subscales of the target variables (EF, EI, and SHT) and mathematical skills (MPR and calculation). Finally, for Objective 3, comparison analyses were performed using U of Mann-Whitney to study the level of EF, EI, and SHT according to the level of performance in MPR and calculation. For these latter comparative analyses, two categories were established for the performance in MPR and calculation: low-medium level (1-49th percentile), and medium-high level (50th-99th percentile). The effect size was calculated with the Psychometrica website (https://www.psychometrica.de/effect_size.html), interpreting all values according to Cárdenas and Arancibia (2014). The data were interpreted with a significance level of $p \leq .05$. The analyses were performed using SPSS v.25 software (IBM Corp, 2017) and Jamovi v.2.3.26 (The Jamovi Project, 2022).

Results

Most of the scores have been placed within the average values established by each instrument. However, in *phonological fluency* ($M = 3.41$ decatype; corresponding to a T-score of 38) the scores were slightly below the average level set by the test (see Table 1). No significant differences have been found according to socioeconomic level, but, in the case of sex, differences have been found in SHT ($p = .003$; $d = 0.746$) with a medium effect size ($d \geq 0.50$; ≤ 0.80).

To achieve the objective 1, which aimed to study the relationship between the target variables (EF, SHT, and EI) and mathematical skills (MPR and calculation) while controlling for the effect of the IQ, partial correlations have been made. As can be seen in Table 2, MPR correlated significantly with the overall score of all three target variables (EF, SHT, and EI), whereas calculation correlated with EF and SHT. Moreover, after controlling for IQ, the same correlations were maintained. These partial correlations showed a small effect size (between .10 and .30), except in the case of the correlation between MPR and EF, which showed a medium effect size (*rho* = .401).

For objective 2, which aimed to analyze the relationship between each subscale of target variables (EF, SHT, and EI) and mathematical skills (MPR and calculation), correlations have been made with all the subscales of the study variables (EF, SHT and EI). As shown in Table 3, and in the case of EF, MPR correlated with *phonological fluency* (*rho* = .356, $p = .002$), *planning* (*rho* = .257, $p = .032$) and *inhibition* (*rho* = .337, $p = .004$), whereas calculation only correlated with *planning* (*rho*=.263, $p = .028$). In the case of EI, MPR correlated with the *intrapersonal* scale (*rho* = .282, $p = .018$) and *adaptability* (*rho* = .383, $p = .001$), whereas no significant correlations were observed with calculation. Finally, within SHT, all the scales except for *place of study* had significant correlations with MPR, whereas calculation correlated with *student's physical fitness* (*rho* = .323, $p = .006$), *study techniques* (*rho* = .323, $p = .006$), and *exams and exercises* (*rho* = .298, $p = .012$). These correlations showed an effect size between small (between .10 and .30) and medium (between .30 and .50).

Regarding the objective 3, which aimed to study the differences in the scores of EF, SHT, and EI according to the level of performance in calculation and MPR (low-medium or medium-high), significant differences were observed in EF ($p = .013$, $d = 0.623$) and EI ($p = .013$, $d = 0.620$) depending on the level of MPR (see Table 4), such that those who scored high in MPR also had a higher level of EF and EI. In calculation, significant differences were found in EF ($p = .014$, $d = 0.611$) and SHT ($p = .020$, $d = 0.576$), reflecting that the higher the EF and SHT scores, the higher the level in calculation. These differences have shown a medium effect size (*d* between 0.50 and 0.80).

Discussion

The present study aimed to analyze the relationship between calculation and MPR skills with EF, EI, and SHT in children aged 9-12 years. For this purpose, the relationship between MPR and calculation with the different study variables and their corresponding subscales was analyzed, as well as comparative analyses to see the differences in EF, EI, and SHT scores according to the level of performance in MPR and calculation. No significant differences were found depending on socioeconomic status, but there were differ-

Table 2
Results of partial correlational analyses between the study variables

	MPR	Calculation	
	rho	*rho*	
Zero-order correlations (without controlling for IQ)	Executive Function	.464**	.338**
	Emotional Intelligence	.335**	.157
	Study Habits and Techniques	.355**	.325**
Partial correlations (controlling for IQ)	Executive Function	.401**	.259**
	Emotional Intelligence	.273**	.068
	Study Habits and Techniques	.286**	.237*

Note. N = 70; MRP = Mathematical Problem-Solving; IQ = Intelligence Quotient.
* $p < .05$.
** $p < .01$.

Table 3
Results of correlational analyses with the domains of each variable

	MPR	Calculation	
Components		*rho*	*rho*
Executive Function	Phonological fluency	.356**	.161
	Semantic fluency	.127	.150
	Sustained attention	.217	.149
	Cognitive flexibility	.191	.134
	Planning	.257*	.263*
	Inhibition	.337**	.211
Emotional Intelligence	Intrapersonal	.282**	.095
	Interpersonal	.200	.063
	Adaptability	.383**	.173
	Stress management	.126	.099
	General mood	.213	.169
Study Habits and Techniques	Attitude towards study	.254**	.233
	Place of Study	.159	.070
	Student's physical fitness	.290*	.323**
	Work plan	.318**	.201
	Study techniques	.322**	.323**
	Exams and exercises	.266*	.298*
	Works	.293*	.208
IQ		.356**	.354**

Note. N = 70; MRP = Mathematical Problem-Solving.
* $p < .05$.
** $p < .01$.

Table 4
Differences in the variables according to the level of MPR and calculation

	Level (n)	Executive Function			Study Habits and Techniques			Emotional Intelligence		
		Range	*U*	*d*	Range	*U*	*D*	Range	*U*	*d*
MPR	L-M (32) M-H (38)	28.91 41.05	397**	0.623	41.55 49.37	443	0.478	83.18 99.50	398**	0.620
Calculation	L-M (28) M-H (42)	28.20 40.37	384**	0.611	41.52 51.98	395*	0.576	90.17 100.48	478	0.319

Note. n = number of subjects at each level (*N* = 70); L-M = low-medium level; M-H = medium-high level; MRP = Mathematical Problem-Solving.
* $p < .05$.
** $p < .01$.

ences as a function of sex, with girls obtaining a significantly higher score in SHT, coinciding with the findings of Capdevila Seder and Bellmunt Villalonga (2016). According to these authors, women tend to have a better attitude towards studying, which promotes higher academic motivation.

Regarding objective 1, and given the importance of IQ in the literature (Song & Su, 2022), partial correlations were calculated between the study variables to analyze the relationship between the variables controlling for IQ. These analyzes have revealed that the MPR ability correlated with all three target variables (EF, EI, and SHT), whereas calculation correlated with EF and SHT (but not with EI). These correlations were maintained even when controlling for the effect of IQ, observing only a slight decrease in strength. These results coincide with those that ratify the relevance of EF (Filippetti & Richaud, 2017; Ribner et al., 2017), EI (Agnoli et al., 2012; Muhtadi et al., 2022) and SHT (Odiri, 2015; Tok, 2013) in mathematical learning. Thus, these partial correlations would indicate that there is still a significant relationship between MPR and EF, EI, and SHT, and between calculation and EF and SHT even if the level of IQ remains constant.

Concerning objective 2, and after finding out the relationship between the global scores of the study variables (EF, EI and SHT) with MPR and calculation, correlational analyses have been carried out to see with which subscale of each variable correlations occur. These correlational analyses, with each component of EF, EI, and SHT variables, yielded differential correlations between the two mathematical skills (MPR and calculation). Within EF, *phonological fluency*, *planning* and *inhibition* have been significantly correlated with performance on MPR, while only *planning* was correlated with calculation. According to Partanen et al. (2020), *planning* is essential to mathematical performance, especially in MPR, and can predict the risk of having mathematical difficulties. In fact, *planning* plays an important role in mathematical tasks, because it involves goal-oriented thinking, self-control, and metacognitive skills that enable the implementation of appropriate strategies to solve the mathematical problem or calculation task (Lehman et al., 2010). In case of *inhibition*, it is involved in most MPR tasks, as it is necessary to select the right answers, suppress inappropriate mathematical ideas or behaviors, and execute the right plan (Kotsopoulos & Lee, 2012). However, some studies found no relationship between *inhibition* and mathematical performance (Toll et al., 2011). This controversy may be due to the differences in the complexity of the mathematical task and the age of the participants evaluated, because *inhibition* would be more relevant to more complex mathematical tasks, such as MPR (Gastañaduy et al., 2021), and in older children (Cragg & Gilmore, 2014; Toll et al., 2011). Instead, Jacob and Parkinson (2015), despite indicating that the evolutionary development of EF may be one of the causes of inconsistent results, observed fairly stable correlations across different age groups (3-5; 6-11; and 12-18 years). The fact that *phonological fluency* correlated with MPR, but not with calculation, could be explained because specific language-related processes also intervene in MPR, whereas general domain and specific mathematical processes participate in calculation (Peng et al., 2016). Moreover, Filippetti and Richaud (2017) point out that, in calculation tasks, *working memory* would be the most relevant executive domain, which has not been measured in this study.

In the case of EI, *intrapersonal* dimension and *adaptability* correlated with MPR, while no EI dimension correlated with calculation. According to Agnoli et al. (2012), complex emotional resources, such as the components of EI, are needed when the demands are greater than the student's cognitive resources. Thus, MPR could be interpreted as having correlated with EI because it is more cognitively complex than calculation skills (Gastañaduy et al., 2021). These results reflects that MPR is related to the knowledge and management of one's own feelings (*intrapersonal*) and the ability to manage and guide one's own behaviors and emotions in changing situations (*adaptability*), which is closely related to the idiosyncrasy of MPR (Herrera et al., 2020). According to these latter authors, the *intrapersonal* dimension could promote language skills through improved skills in communication, reflection and comprehension of written and spoken language. Thus, considering that language skills are also involved in MPR, this could explain why the *intrapersonal* dimension has correlated with MPR and not with calculation. Regarding *adaptability*, higher levels in this dimension allow one to manage changes with a lower level of stress, which favors a better development of mathematical skills (Brock & Curby, 2016). Therefore, EI could be a relevant feature in the effective coping with stress related to mathematical learning and, mainly, to MPR (Ramirez et al., 2016), emphasizing the ability to regulate and interpret one's own affective stimuli (Agnoli et al., 2012).

Within the subscales of SHT, a greater number of correlations with MPR have been observed than with calculation. The MPR ability correlated with all the scales (*attitude towards study, student's physical fitness, work plan, study techniques, exams and exercises*, and *works*) except for the *place of study*, whereas calculation was associated with three scales (*student's physical fitness, study techniques*, and *exams and exercises*), but not with the *attitude towards study, place of study, work plan*, or *works*. These results coincide with previous studies (García et al., 2007; Quílez-Robres et al., 2021), highlighting the relationship of good SHT with mathematical performance, as they constitute one of the most important individual variables that favor the development of awareness of mathematical learning (Gudaganavar & Halayannavar, 2014; Odiri, 2015). Thus, the *attitude towards study* (self-knowledge about the reasons for studying) is presented as an important factor of MPR performance (Capdevila Seder & Bellmunt Villalonga, 2016). Given that MPR is a mathematical ability that implies greater cognitive complexity than calculation (Fuchs et al., 2018: Gastañaduy et al., 2021), the *attitude towards study* would be essential to maintain motivation and persistence until the problem is solved. *Work plan* correlated with MPR, but not with calculation, reflecting that, unlike calculation, MPR requires the establishment and sequential execution of a plan to adequately solve the problem (Kotsopoulos & Lee, 2012). This relates to the aspects and phases needed for task performance (*works*), a scale that also correlated only with MPR. The *place of study* scale did not correlate with either of the two mathematical skills, indicating that environmental aspects such as lighting, distractions, or noise are not strongly related to mathematical skills in elementary school students. Taking into account that previous studies carried out with preteens or adolescents found a correlation between this variable and mathematical performance (Capdevila Seder & Bellmunt Villalonga, 2016), these results suggest that the *place of study* would begin to relate to performance as of the secondary stage, whereas, in elementary school, where the academic demands are still low, it would not be so relevant. Finally, *student's physical fitness* has correlated both with MPR and calculation, highlighting the relevance of personal conditions (health, food, rest, emotional stability or balance) (Álvarez & Fernández, 2015) for adequate performance in MPR and calculation.

Finally, regarding objective 3, comparison analyzes have been carried out to verify the differences in the scores of the study variables (EF, EI, and SHT) depending on the level of performance in MPR and calculation (low-medium and medium-high). Significant differences were observed in the scores of EF and EI depending on the level of performance in MPR, such that students with higher MPR performance scored higher in EF and EI. Regarding calculation, students who showed higher performance also scored higher in EF and in SHT. These results have shown that students with lower development of EF and EI present a lower level in the abilities of MPR and that students with a low level in EF and SHT also obtain a lower performance in calculation. This highlights the important of EF for the development of the two mathematical skills (MPR and calculation) (Filippetti & Richaud, 2017; Ribner et al. 2017; Toll et al., 2011), EI for the development of MPR (Herrera et al., 2020) and SHT for the development of calculation. MPR involves a greater amount of higher-order cognitive resources, based on the fact that EF act as a cognitive control system that regulates and manages the necessary resources oriented to attaining a goal (Menon, 2016). Therefore, this would explain the involvement of EI in MPR by promoting an effective coping with stress related to MPR learning (Agnoli et al., 2012; Das & Das, 2013). Calculation tasks require recovering previously learned numerical facts from memory (Qin et al., 2014), which would explain the relevance of appropriate SHT. These analyses have been carried out with the aim of providing more interpretable and applicable information in the field of education, as they offer valuable information for understanding the interaction of underlying skills (EF, EI, and SHT) that may affect mathematical learning, as well as the possibility of enhancing mathematical learning by reinforcing the development of these underlying skills.

The small sample size is a limitation that must be considered when interpreting and generalizing the results. The impossibility of ensuring compliance with the guidelines provided to families regarding the application of the online questionnaires is another limitation of the study. In the present study, variables that previous studies have indicated as relevant for mathematical learning have been measured, but the perception of competence has not been assessed, an aspect that could influence the development of mathematical skills (Forsblom et al., 2022). In addition to this, some of the analyses of the psychometric properties of the instruments used with the sample of the present study have yielded reliability coefficients below the minimum required (ENFEN = 0.617; *student's physical fitness* = 0.617; *study techniques* = 0.568; *works* = 0.359; *expressive vocabulary* = 0.604), which requires caution in the interpretation of the results with respect to these scales. It is also important to consider that categorizing continuous variables (for objective 3), despite being categories provided by the test itself, may imply the loss of statistical information. Along with it, the design implies the absence of causality so, strictly speaking, no antecedent and consequential factors can be extracted. Therefore, in future studies, it would be appropriate to use a quasi-experimental design with larger samples to elucidate the direction of the relationships, together with a longitudinal approach that allows observing the evolutionary relationship between the constructs studied. Thus, one could verify possible variation depending on the educational stage, as previous studies indicate. In addition, it would be useful to establish a control protocol for the online questionnaires, evaluate the EF with another performance test with justified validity and reliability, as well as to analyze the interaction and mediation of the perception of competence. Likewise, it would be appropriate to study implication of *working memory*, the differential implication of fluid and crystallized intelligence and the predictive capacity of the different variables depending on the level of performance in each mathematical skill. Another aspect that should be considered in future studies is the involvement of different cognitive components depending on how the mathematical task is presented (analog, auditory-verbal, or visual-Arabic).

Summing up, the study concludes by highlighting that MPR is mainly related to higher-order cognitive processes (EF), but also to EI and SHT. In addition, there are significant differences in the EF and EI scores depending on the level of performance in MPR, where the higher the score in these variables (EF and EI), the higher the level of performance in MPR. Calculation skill, in turn, is associated with EF and SHT, and there are significant differences in the level of these variables (EF and SHT) depending on the level of performance in calculation, where a higher score in these variables implies a higher performance in calculation. These results show that EF, EI, and SHT play a differential role in the development of calculation and MPR skills in elementary school students. All of this provides valuable information to the educational field, enabling the implementation of programs that improve mathematical learning from a neuroeducational perspective. On the one hand, there would be the implementation of preventive programs aimed at enhancing, in all students, the processes underlying MPR skill (EF, EI and SHT) and calculation skill (EF and SHT). On the other hand, additional interventions aimed at improving students' specific mathematical difficulties could be considered, also assessing the level of development of the underlying processes (EF, EI and SHT) and acting both on the mathematical skills (MPR and calculation) and on the domains of each underlying processes.

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