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CORRECTION OF LEARNING DISORDERS BY OPTIMIZING THE DEVELOPMENT OF SPATIAL AND TEMPORAL ORIENTATION

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ABSTRACT. Learning to read, write and calculate are proving to be some of the most significant cognitive processes in early education. The objective of this systematic review is to explore the associations between the psychomotor component and the academic achievement in writing, reading, and mathematics. An organized and methodical research of electronic databases was completed in order to determine significant studies. Twenty eligible articles were strictly evaluated, with extracted and summarized keywords. The two components of the psychomotor activity that influence reading were primarily the orientation ability and the fine motor skill, which is the one responsible for the correct spelling of "mirror-writing". Differences in motor function were observed after intervention programmes. The results of all researchers have shown that there is a link between dysgraphia, dyslexia and the orientation ability or visual perception. Meanwhile, the role of cognitive and motor skills that underpinned mathematical performance was highlighted, and children who had a high capacity for spatial and visual orientation benefited from a better understanding and perception of geometric figures. However, the importance of students' spatial reasoning in relation to mathematics was identified, but only in terms of geometry. Poor quality of spatial notions has been found to be one of the causes of delay in the acquisition of reading, writing and mathematical calculation. The role of fine motor skills in the writing process was also noted, being of real importance in times when the child manipulates the writing tool and puts a word or a sentence on the page.

Keywords: *dyslexia, dyscalculia, spatial and temporal orientation, psychomotricity*

REZUMAT. ***Corectarea tulburărilor de învățare prin optimizarea dezvoltării spațiale și temporale: analiză de tip review.*** Învățarea scrierii, citirii și calculului se dovedesc a fi unele dintre cele mai semnificative procese cognitive în educația timpurie. Scopul acestei revizuiri sistematice este de a examina asocierile dintre componenta psihomotrică și performanța academică în scriere,

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citire și matematică. A fost efectuată o căutare sistematică a bazelor de date electronice pentru identificarea studiilor relevante. Douăzeci de articole eligibile au fost evaluate critic, cuvintele cheie fiind extrase și sintetizate. Cele 2 componente ale psihomotricității care influențează lectura au fost cu precădere capacitatea de orientare și abilitatea motorie fină, cea responsabilă de ortografia corectă a literelor și de evitarea scrierii tip ,,oglindă''. După programele de intervenție, s-au observat diferențe la nivel motor. Astfel, rezultatele tuturor cercetărilor au arătat că există o legătură între disgrafie, dislexie și capacitatea de orientare sau de percepție vizuală. În paralel, s-a evidențiat rolul abilităților cognitive (spațiale) și motorii care au stat la baza performanței matematice, iar copiii care au avut o capacitate de orientare spațială și vizuală ridicată, au beneficiat de o mai bună înțelegere și percepție a figurilor geometrice.

Totuși, s-a identificat importanța raționamentului spațial al elevilor în raport cu matematica, dar doar în ceea ce privește geometria. S-a constatat că slaba însușire a noțiunilor spațiale poate fi una dintre cauzele întârzierii în însușirea cititului, scrisului și calculului matematic. De asemenea, s-a remarcat rolul abilităților motorii fine în procesul de scriere, fiind de o reală importanță atunci când copilul manipulează instrumentul de scris și așază în pagină un cuvânt sau o propoziție.

Cuvinte cheie: *dislexie, discalculie, orientare spațio-temporală, psihomotricitate*

Introduction

Learning to read, write and count are proving to be some of the most significant cognitive processes in early education which develop from others, such as experiencing one's own body, self-control and coordinating one's own body movements. In all cultures, the existence of children who have difficulties in acquiring language and mathematics, without showing any kind of problems in other fields, generates an increasing interest in the scientific community's study of the matter, which is currently still little known. The current situation and research that includes the subject of learning disorders presents a component that is closely related to them, namely the psychomotricity.

The "specific learning disorder" term refers to a heterogeneous group of neurobehavioral disorders that manifest as typical and constant difficulties in the powerful acquisition of reading, writing, and math skills. People with these deficits do not generally present any sensory disorders, but have a normal intellectual capacity and can be included in the regular school circuit, enjoying a regular socio-cultural opportunity (Benedicto-López & Sara, 2019). In the most comprehensive approach we can acknowledge the learning disorders to

be cognitive situations which affect one's ability to receive, process, investigate or store information. The learning disorder is defined as an unexpected predicament and persistence in acquiring reading, writing, calculation, and drawing skills, despite normal intelligence and proper schooling (Málaga & Arias, 2010). The field of learning disordes is extremely complex and constantly evolving. Thus, a broad classification would divide these difficulties into two broad groups: the group of dyslexic children (the most common one, including children with reading, writing, and literacy dfficulties) and the group of discalculated children with non-verbal struggles (Snowling et al., 2003).

Dyslexia is a neurodevelopmental disorder characterized by difficulties in learning to read and spell, which is typically associated with phonological deficits (Snowling and Hulme, 2012; Vellutino, et al., 2004). Nonetheless, even if a phonological deficit appears to be the major proximal causal risk factor for dyslexia, there is evidence which supports the idea that dyslexia may be the product of several risk factors, and children with a wider range of cognitive and sensorimotor deficits are more likely prone to develop reading problems (Carroll, et al., 2016; Pennington, 2006; Pennington et al., 2012; Snowling, 2008; van der Leij et al., 2013).

Snowling and Melby-Lervåg (2016) analyzed a total of 15 studies performed on kids with dyslexia. Besides the extensively reported phonological deficiency, a meta-analysis showed that those who continue to be diagnosed with dyslexia face a wide variety of language difficulties. There is also suggestive evidence from neurophysiological studies that biomarkers of dyslexia prominent in childhood include difficulties in processing speech sounds (Leppänen et al., 2011; van der Leij et al., 2013). Altogether, these studies are perfectly stable with the concept that dyslexia is a type of language learning disorder.

On the other hand, although being less studied, but with a similar prevalence, there is dyscalculia. "Dyscalculia includes all the difficulties related to the concept of number, arithmetic calculation and mathematical reasoning" (Cadirola et al., 2016).

Some authors who have studied this matter (Gil-Madrona, 2013; Mendiara, 2008) state that both language and psychomotor skills are processes which are learned together in the human development. For his part, Berruezo (2008) affirms that a set of dimensions interacting with each other also contributes to the development of writing and reading skills: fine, gross motor skills, spatial and temporal orientation, laterality, balance. In this order, various research coincide in the affirmation of the previously written ones, which support the same idea, as that the psychomotor system has a great influence on the development of reading / writing (Ashford et al., 2006; Berruezo, 2008; Mendiara, 2008; Teixeira et al., 2015).

According to the Psychiatry American Association (1995), the preponderance of motor difficulties in child population varies from 6% to 8%. Of these percentages, it is predicted that 30% to 50% also have some sort of associated learning disorder, such as dyslexia or other different language difficulties (Ramus et al., 2003; O'Hare & Khalid, 2002; Visser, 2003). Of all these components of the psychomotor skills, spatial and temporal orientation is considered essential for learning to write. Due to this, girls and boys learn to locate their own body in space, an ability which is also reflected in the notebook, the child becoming aware of the orientation of writing, i.e. from left to right or from top to bottom. If this neurofunction is not developed and assimilated correctly by students, dysgraphia problems occur, which causes students to omit letters, enlarge them, replace them and so on (Marroquín et al., 2014). According to Espinoza (2003), "the elementary functions that need to be developed to achieve a good literacy process are: body scheme, lateral dominance, spatial and temporal orientation''. Troubles in reading and writing areas are most commonly connected to motor coordination difficulties (Smits-Engelsman et al., 2001) whilst mathematical computational difficulties are linked with perceptual-motor problems, for instance spatial and temporal orientation and laterality (Bastos, 2006).

Numerous studies have emphasized the positive correlation between mathematical and spatial skills (Berciano et al., 2016; Cheng & Mix, 2014; Fernandez-Mendez, 2020). Much of this evidence comes from the fact that those who perform better on space tasks tend to perform better on math ability tests (Holmes et al., 2008; Rasmussen and Bisanz, 2005). There are certain studies that confirm that mathematics has a spatial nature (ex. Jones, 2002). Other studies suggest that in order to perform in mathematics, students must have the ability to imagine and visualize things and objects in space (Shea et al., 2001; Wei et al., 2012).

Objectives and hypotheses

Generally, a broader understanding of how the different components of motor competence are related to mathematics and reading skills in children in the early years of school is needed. Given this context, the aim of this systematic review is to examine the associations between the psychomotor component and the academic performance in mathematics and reading. Thus, the questions to be answered are:

1. According to other studies, is there a link between psychomotor skills and reading and writing disorders?

2. According to other studies, is there a link between psychomotor skills and computational disorders?

If the answers prove to be affirmative, the systematic review will also answer other questions:

3. According to other studies, which component of the psychomotor activity influences writing, reading and calculation disorders?

4. Is the ability of spatial and temporal orientation a determining factor in ameliorating writing, reading and arithmetic disorders?

Thus, the issued hypotheses are:

1. It is assumed that there is a link between psychomotor activity and learning disorders.

2. Spatial and temporal orientation, as a component of the psychomotor activity, positively influences academic performance in writing, reading and arithmetic.

Material and method

Study identification

In order to identify the relevant studies, it was performed a comprehensive search of databases. Electronic databases (PubMED, PsychINFO, Web of Science) were checked out using keywords such as: dyslexia, dysgraphia, dyscalculia, spatial orientation, temporal orientation, psychomotor activity, visual skills, visual-spatial skills, learning disorders, children, academic performance, spatial skills.

Study selection

In order to be included in this systematic survey, the research was in line with the following criteria:

Inclusion criteria:

- a sample of preschool and school children, aged between 5 and 15 years old;
- a sample of children diagnosed with one of the learning disorders, but also undiagnosed at that time;
- studies published between 2011-2021;
- experimental studies had to contain at least one component of psychomotor activity, in relation to one of the learning disorders;
- studies in English and/or Spanish;

Exclusion criteria:

-sample of children diagnosed with an intellectual/neurodevelopmental disorder/other associated comorbidities (ADHD, low IQ, autism, coordination disorders, etc.);

-studies that focused on an overall score of academic performance and not on one of the disorders were excluded;
-studies published in a language different than English/Spanish, without the possibility of translation.

The following figure (figure 1) shows the plan of the Prisma diagram used for the selection of studies:

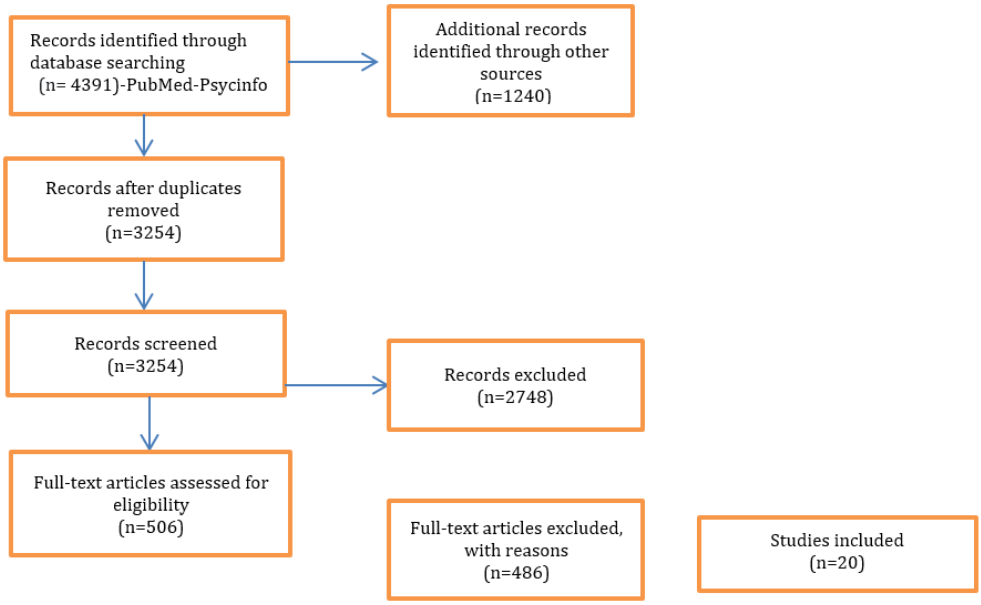

Figure 1. The Prisma diagram scheme

Results

After the specific selection's competition, 20 studies were considered worthy for inclusion. These studies, which were contained in the review, were published between 2011 and 2020. The total sample sizes involved in these studies ranged from 19 to 12.099 children. The participants in the study were mainly children, from the primary school, aged between 5 and 14 years. Among them, a total of 242 children were diagnosed as having a learning disorder before being included in the study, either by testing or by being characterized by a teacher.

A number of tools were used to assess the various components of psychomotor activity: questionnaires, observation sheets, spatial and temporal orientation test (TOTE), BOT-2 motor skills test (Bruininks-Oseretsky Test of Motor Proficiency, Bender Gestalt test, Motor development scale (MDS) described by RosaNeto (2002), Raven Test - Colorful Progressive Matrix Scale (MPC), Test of Visual-Perceptual Skills, Movement Assessment Battery for Children, Spatial Skills Test, Motor Assessment Scale, Spatial Reasoning Instrument, Movement Assessment Battery for Children-Second Edition (MABC-2 ; Henderson, Sugden & Barnett, 2007), Mental rotation task. A wide collection of tools has also been used to assess academic acchievement in mathematics, reading and writing: questionnaires, observation sheets, Reading and Writing Analysis Test (TALE), Motor Dysgraphia Subtest (25 items) - Mabel Condemarín, Learning and Vocabulary Questionnaire (30 items)-David Wechsler, Dysgraphia Scale, Desempenho Escolar Tests (TDE), Mathematics test-geometry, Wechsler Test 2nd Edition (WIAT-II), Block design, Pattern Construction subscale of the BAS-II, NFER PiM, Mathematical achievement etc.

It is important to mention that out of the 20 studies included, a total of 12 studies address reading disorders (dyslexia), of which 8 are focused on writing (dysgraphia), and 8 are aimed at mathematical disorders. The 20 relevant studies are set out in Table 1:

Table 1. Bibliographical sources included in the review

AUTOR	METODS	RESULTS
Klonari, A., Styliani Passadelli, A. (2019)	Objective: a.Investigation of spacial thinking b. The difference between dyslexic and non-dyslexic children in terms of orientation -50 children aged 13-14 (25-dyslexic, 25 non-dyslexic) A 3-part questionnaire: Demographic data, spatial thinking test, geographical thinking test	1) Non-dyslexics scored 222 points and dyslexics 152 points (p 0.002) 2) Non-dyslexics scored 255 points and dyslexics scored 117 (p .000) Non-dyslexics scored 102 and dyslexics scored only 35 (p 0.001) 3) The total score obtained by the non-dyslexic students in all exercises was 612, while dyslexics obtained 482 (p 0.042).
Timbila, H., Jesús, M. (2017)	Objective: To analyze the importance of spatial orientation. • Establishing the characteristics of the spatial orientation in kids aged 5	Between 50 and 75% of teachers say that almost always orientation in space facilitates the reading-writing process More than 40 of the children have difficulties with spatial orientation

	• Establishing the types of strategies that teachers use to develop spatial orientation 50 children- 5 years Testing tools: questionnaire / observation / study The orientation in space variable: questionnaire / observation / study - laterality	1. There is a direct relationship between spatial orientation and the reading-writing process. 2. Spatial orientation develops and matures in different stages 3. There are various methods to help with the reading-writing process
Marroquín, T., Vanesa, E. (2014)	Objective: Determining the relationship between spatial and temporal orientation problems and dysgraphia among girls and boys in the third grade Elaboration of an intervention guide in the spatial and temporal orientation, which should prevent the dysgraphia of the students. Tools: 1. Reading and writing analysis test (T.A.L.E.) 2. Spatial and temporal orientation test (T.O.T.E.) -208 children, the third grade	1. According to the results of the TALE test, Writing Subtest, 60% of girls and boys make mistakes in writing. 2. The spatial and temporal notions which they do not identify are: size 43%; hours of the day 44%; succession of duration 75%; left-right orientation 75%; horizontal-vertical 44%; trajectory appreciation 54%. In spontaneous writing they present: irregularities/ oscillations. Regarding copying, there are speed errors while on dictation there are substitutions, omissions and consonant changes 3. The average percentage of girls and boys who make mistakes is 60%. 4. The predominant dysgraphic errors in writing are in 24 indicators (71%). 5. The exercises or activities that must be performed in order to correct the problems of orientation in space and time, as well as avoiding dysgraphia, are in the following dimensions: duration, order and succession, rhythm, left-right orientation, direction in space and location.
Basantes-Colcha, C. P., Coello, M. J. C (2017)	Objective: a. Development of psychomotor activity through movements and games,	• The activities carried out with the students and parents who applied the guide and the psycho-pedagogical intervention technique

	b. Improving children's writing through graphic expressions, letters, drawing and graphomotor exercises. c. The implement of a support program for teachers Tools: a. Reading and writing analysis test (T.A.L.E.) b. Observation sheet c. Questionnaire intervention + elements of orientation in space, time, visual coordination, fine motor skills -20 children, fourth grade	helped to decrease the dysgraphia of the boys and girls who had this problem, reaching very satisfactory results both quantitatively and qualitatively. • Children's writing has been greatly improved, by 90%
Cusín Yacelga, D. A., Cusín Yacelga, M. M. (2016).	Objective: Diagnosis of children with dyslexia and dysgraphia Identifying the characteristics of learning (reading-writing) in boys and girls in the third and fourth grade. The development of a teaching guide for teachers, students and parents containing strategies, techniques, and workshops suitable for the development of both reading and writing Tools *Questionnaire* *Observation Sheet* *Bender Gestalt Test* -98 children (51 from the third grade and 47 from the fourth grade)	There are greater difficulties in the third grade children, with higher percentages of the difficulties of visual motor coordination and perception of shapes. Regarding the results of the other tests applied, it is found that learning disorders have a higher incidence in children aged 7. The entire number of boys and girls who show symptoms of dyslexia and dysgraphia in the studied population is 39. The highest incidence is in the third grade, who have a poor reading comprehension, rigidity in writing and posture.
Okuda, P. M. M, Martins, P. (2014).	Objective: The characterization and comparison of students with learning difficulties' motor performance in relation to students with normal academic performance. Tool: BOT-2 (Bruininks-Oseretsky Test)	Students with dyslexia had lower physical activity as compared to the others. However, both groups in this study performed lower than expected for their age. A statistically compelling contrast was observed between the groups, especially in the areas regarding fine

	-79 children, aged 8-11 Group 1: dyslexia-19 Group 2: without dyslexia-60	motor skills, manual control, manual coordination, endurance and nimbleness.
Cacuango Chicaiza, M. (2020)	Objective: Determining the skills development in the motor and sensory functions. Identifying the skills and functions that contribute to reading-writing A bibliographic review was conducted on studies similar to the study variables, which guides and provides guidance for research development. 3 stages: Sensory stage - motor or sensory motor. Pre-operational stage from 2 to 7 years old. The stage of concrete operations from 7 to 11 years old.	The aspects which influence the development of the basic functions during the literacy process are: the cognitive development, the motor development, posture, tonicity, muscle coordination, balance, laterality, space, time and rhythm. The basic functions that affect the development of children's reading are the visual motor coordination, phonological awareness, temporal space, rhythm, laterality and directionality. The basic functions that affect the writing process are: muscle tone, posture, balance, attention, memory, dissociation of movements, and laterality.
Gallardo, Y. P., Gallardo, A. B., Cantuña, P. T. (2016)	Objective: studying spatial intelligence and its influence on reading / writing in third grade boys and girls Tools: Raven Test - Colorful Progressive Matrix Scale (MPC) Literacy Analysis Test - T.A.L.E - determines the level of reading and writing -85 children from the third grade	Out of the total population, just over two quarters obtained average scores in terms of spatial intelligence diagnosis, a little bit over a quarter are below average, while less than a quarter are at a deficit level. 10% of the evaluated children obtained a rank II score, making them children with a superior spatial intelligence to their age. Those who obtained a rank III are children evolved according to the requirements for their age, and in the last group, rank IV, are children who need attention and restructuring of the necessary skills for visual perception, such as: visual attention, visual memory, motor coordination; as well as in spatial structures: spatial orientation, spatial organization and spatial structuring,

Palacios-Chachapoyas, K. (2018)	Objective: Identifying a positive relationship between visual-spatial skills and writing / vocabulary. -54 students, aged 10-11 Motor dysgraphia subtest (25 items) - Mabel Condemarín Learning and vocabulary questionnaire (30 items) - David Wechsler	Significant correlation between visual-spatial skills and meaningful learning / vocabulary: -, 268 (Sig., 050)
Fernani Luiz, D. C. G., Prado, M. T. A., Fell, R. F., Reis, N. L., Bofi, T. C., Ribeiro, E. B., Blake, M. T., Monteiro, C. M. (2013)	Objective: Motor development assessment in children aged 6 to 11, with learning problems and school characteristics of delayed motor development, pre and post the motor intervention' application program (6 months, one hour / week) The intervention included jumping, moving, combining elements, exercises on music. Tools: Motor Development Scale (MDS) described by RosaNeto (2002), which assesses the fine motor skills areas, global motor skills, balance, body scheme, spatial and temporal orientation.	At the end of the intervention, higher scores were recorded, the data showing a numerically substantial distinction amongst the average of the initial tests and those from the re-evaluation. The motor ratios equivalent to the regions in the body scheme, spacial and temporal direction In the initial classification conducted one by one in the evaluation, most kids had a motor growth assigned as "normal to low". Despite that, in the reassessment, merely 4 of them did not evolve and remained to be categorized as "normal to low", mostly changing toward "normal to medium".
Silva, J., Beltrame, T. S., Oliveira, A. P., Sperandio, F. F. (2012).	Objective: The study intended to recognize learning and motor troubles in students with low educational achievement. 19 children, 10 years old, classified by teachers as having learning disorders Tools: *Desempenho Escolar Tests* (TDE) indicates which learning school domains are maintained or affected in the specific subject discussed (reading, arithmetic, writing) *Movement Assessment Battery for Children* – 4 task sets, which	With the exception of the arithmetic test, participants had a below average academic performance for their educational status, for both sexes, as reported by the TDE parameters. The boys had even a greater average assess in reading, writing and in the general outcome of the TDE, while the girls had a superior development in arithmetic, yet, according to statistics,this discrepancy was not established. Amid the 19 students appointed by educators, only one revealed no indication of a learning disorder,

	include dexterity, ball skills, balance, etc.	whereas the other children were pronounced with difficulties in minimum one scholarly ability (many times in reading and writing). Regarding the motor indicator, it turned out that five of the children involved had limited motor issues.
Fusco, N., Giseli, D. G., Capellini, S. A. (2015).	Objective: Checking the effectiveness of a perceptual-visual and motor intervention program for students with dyslexia. -20 students, aged 8-11, from the third and fourth grade Group I (GI; 10 students with developmental dyslexia) and Group II (GII; 10 students with fine school performance). A perceptive and vision-motor intervention program was implemented, which included targeted-motor coordination exercises, visual memory, vision-spatial coordination. In the pre and post test situations, both groups were tested of Visual-Perceptual Skills, and for writing the Dysgraphia Scale test.	The examined statistical findings demonstrated that one as well as the other group of students had dysgraphia in the pre-test phase Regarding perceptual-visual skills, GI showed lower performance compared to GII, including when it came to the writing quality. After experiencing the intervention program, the GI enhanced the medium of the right answers and strengthen the quality of the handwriting.
Macdonald, K., Milne, N., Orr, R. (2020).	The focus of this survey was to investigate the connections between fine and gross motor skills and academic performance in mathematics and reading in preparatory class children. *Tools:* Motor competence Complete Bruininks-Oseretsky Engine Proficiency Test Form (BOT-2), *Academic performance in mathematics and reading* Wechsler Test Second Edition (WIAT-II) -5 of the 9 individual subtests. -55 children, 25 boys-30 girls, class 0, 6-8 years old	A significant positive association was found between the scores from the total motor tests and the scores of the mathematical tests ($r = .466$, $p < .001$). Scores in terms of fine motor skills were significantly associated with both mathematical scores ($r_s = .572$, $p < .001$) and reading scores ($r_s = .476$, $p = .001$).

Berciano, A., Jiménez-Gestal, C., Salgado-Somoza, M. (2016).	Objective: Designing a didactic proposal for the development of the classroom orientation, to promote / use mathematics. Evaluation and analysis of content activities. The importance of using spatial orientation exercises from a mathematical perspective is analyzed. A context is presented, the purpose of which is to search for a hidden treasure somewhere in the school. Subsequently, following the curriculum lines, it is analyzed which mathematical processes are used. Eventually, it is examined to what extent the implementation of this activity in a school helps girls and boys to develop the properties of space, especially the three-dimensional one. -20 children, 5 years old	The activity: we worked with certain mathematical concepts related to orientation: up, down, right, left. The exploration of the school took place through a guided intervention and the principles of the proposal mentioned at the beginning were satisfied. The content analysis had different activities completed by the children: listening to the story of the treasure, the answers they were guided by, searching for the treasure by interpreting the icons, verbal communication, etc.
Lowrie, T., Logan, T., Ramful, A. (2017).	Evaluating the effectiveness of a visual space intervention program to determine the effect on students' spatial reasoning and mathematical performance -120 children, 66 control group (10-12 years old), undiagnosed. The program lasted for 10 weeks, 20 hours. Tools: a.Spatial Reasoning Instrument – spatial orientation, visual orientation, mental orientation. Mathematics test – geometry	The space intervention program led to improvements in both spatial ability and mathematical performance in relation to the control group.
Cheng, Y. L, Mix, K. S., (2014).	Objective: investigate a potential causal relationship between spatial capacity and mathematical skills. Pretest-design-posttest intervention -59 children (6-8 years old)- 32 in the experiment group and 27 in the control group.	It has been found that a short spatial orientation intervention can develop mathematical skills. Spatial intervention significantly improved children's scores from post-test, ($t(31) = 3{,}587$, $p = .001$), whereas children in the control group did not ($t(26) = .635$, $p = .53$

	Tools: Spatial skills test, with 32 items. 2 Math tests with 27 and 16 items, respectively Intervention-Working with different objects	
Oliveira, C. C, Capellini, S. A. (2013).	Objective: To describe and to contrast the children's motor performance with developing dyslexia, learning disorders and educational difficulties. -40 students, 7-11 years old GI: 10 students with dyslexia GII: 10 students with learning disabilities GIII: 10 students with learning difficulties and GIV: 10 students with good academic performance Tool: Motor Assessment Scale.	Kruskal-Wallis, Mann-Whitney, Friedman, Wilcoxon Signed Posts and the Spearman correlation, signifying that groups I and II performed lower on the tests of balance and spatial orientation. These groups differed from each other in the gross motor tests, in which the GI scored lower than all other groups and the GII was lower than all other groups in the temporal orientation, while the children belonging to GIII and GIV showed motor skills.
Cetin, S. Y., Kitiş, A., Kösem, F. Ş. (2018).	Objective: To evaluate motor performance in children with dyslexia, through the DSM-IV-TR -28 dyslexic children and 28 without dyslexia, 7-12 years old. Motor skills were assessed with the Bruininks Oseretsky motor skills test (BOTMP 2-SF)	There was a significant difference between the results of the two groups on motor skills, functional status and quality of life ($p < 0.05$).
Gilligan, K. A., Flouri, E., Farran, E. K. (2017).	Objective: This study explored the associations between math and spatial skills in 5 and 7year olds. 12,099 children who participated in both Wave 3 (mean age = 5; 02 [years; months]) and Wave 4 (mean age = 7; 03) 1. Measures included a standardized assessment of the mathematics and construction scale of British Ability Scales II models to assess intrinsic-dynamic spatial skills (BAS-II). 2. NFER PiM is an assessment of mathematical ability and includes a wide range of questions about numbers, shapes, measurement, etc.	The results indicate that there was a significant difference in performance between boys and girls for all tasks, except for the mathematical performance, where male scores were above those of the girls. There were differences between the groups in terms of reading and construction skills. Post-hoc tests revealed significant differences between all SES groups ($p < .01$ for all). Model 1- Word reading at Wave 4 had the highest correlation with NFER mathematical scores ($r = .529$, $p < .001$), followed by Model Construction scores at both Wave 4

(r = .479, p <.001) as well as at Wave 3 (r = .430, p <.001).
Model 2- it was indicated that word reading and the models' construction from Wave 4 had the greatest impact on mathematics scores.
The language measures introduced in step 3 explained 19.8% of the scores obtained in mathematics.
Both spatial and linguistic measures were significant predictors in this model (p <.001 for all).
Model 3
Spatial ability was accounted for 15.4% of the mathematical variation, while language measurement was accounted for 5.0% of the variation.
Model 4- Word reading had the greatest impact on mathematics, followed by the model construction scores (13.5%).

Analysis

All studies addressing the issue of reading and writing disorders have in common the purpose of determining and identifying how the spatial and temporal orientation contributes to the reading and writing process. Out of the 12 studies, 2 present a motor intervention program, 1 with an emphasis on visual-motor coordination exercises, visual memory, visual-spatial coordination, sequential memory (Fusco et al., 2015) and 1 on fine motor skills, global motor skills, balance, body layout, spatial orientation and temporal orientation (Fernani et. al, 2013). Although at the initial tests all children included in these 2 studies were diagnosed with dyslexia and dysgraphia, after both interventions the quality of the handwriting improved. The motor ratios corresponding to the areas in the body scheme, spatial orientation and temporal orientation represent, according to the results, the components from which significant differences were observed, having the highest increase compared to the others. Alongside with the improvement of writing, differences were also observed at the motor level, except for 4 children, who did not evolve, continuing to be classified as having a "low" capacity (Fernani et. al, 2013).

The other 10 studies are not based on an intervention program, but instead they correlate the results of reading and writing tests with motor tests. According to this research, there is an unanimous correlation between the motor component and the ability to read and write. However, one study does

not show low motor abilities in children diagnosed with dyslexia (da Silva et al., 2012). The common results show that even if the writing component includes the ability to process duration, order, sequence, left-right orientation, space and location, the ability to write is largely influenced by fine motor skills and manual control. In addition to the trouble of not placing the letters and words on the page correctly, which is influenced by their orientation and space, these children have writing rigidity and problems holding the pencil. In conclusion, the results of all research have shown that there is a link between dysgraphia and dyslexia and the ability to orient or visual perception in space. While seeming different, the 2 components of psychomotor skills that influence reading, being of real importance, are mainly the ability to orient, along with fine motor skills, which is responsible for the correct spelling of the letters and the avoidance of "mirror" writing.

The 8 studies that address the issue of computational disorders, among others, share the impact of dyscalculia in these deficits, emphasizing its association with spatial and visual skills, except for one study which also mentions the involvement of the fine motor skills (Macdonald et al., 2020). Among these, 2 contain an intervention program with an emphasis on spatial orientation (Cheng and Mix, 2014; Lowrie et. al., 2017). These programs are designed to determine how this spatial component influences children's performance in math. Thus, according to the results, the role of cognitive (spatial) and motor skills which underlie the mathematical achievements of primary school children is being highlighted. Again, as with writing disorders, these studies identify the importance of students' spatial reasoning in relation to mathematical performance, but only in terms of geometry. Spatial orientation, visual and mental orientation are mentioned in the theoretical components of this research, and children who have these skills benefit from a better understanding and perception of geometric figures. On the other hand, in relation to orientation, it is argued that the ability to calculate depends largely on the ability to memorize, then on attention and last but not least on the direction (left-right, up-down) (Gilligan et al., 2017). Still here, it is mentioned that there are several genetic and developmental factors that could contribute to the calculation. However, no link was identified between temporal orientation and mathematical skills.

Discussion

This systematic review examined the significant connections among various elements of motor competence and academic skills in writing, reading, and arithmetic. There was proof that answered positively to the first 2 questions

of the review, namely that there is a link between motor competence and reading disorders, but also between motor competence and mathematics. These confirmations were found especially in students in the first years of school (6-9 years old), the results being substantially supported by those of Mix et al. (2016). To a very large extent, children included in the studies, who had one or more disorders, had a lower level of one or more components of motor skills, and all children diagnosed with dyslexia scored lower on motor tests, compared to the undiagnosed ones. In a survey of a study which compared the motor skills of children with learning disorders with those of children who develop normally, it was found that the former scored lower on both locomotor subtests and those for handling objects. A correlation between these skills and reading was observed, while finding a relationship between mathematics and object control skills. Moreover, this research highlights the relevance of particular interventions that facilitate both motor skills and academic skills (Westendorp et al., 2011), while supporting the confirmation of the first hypothesis.

4 relevant experimental studies were identified, which supported the psychomotor program as an aid to learning disorders. Despite the fact that the samples were composed of children aged 8-9 years, being the most appropriate time to detect certain disorders (second/third grade) this aspect may become valid at older ages, although there are zero or no relevant adult studies to date. Intervention programs included, among others, speed, agility and balance, but significant differences in motor ratios were observed in the area of body scheme and spatio-temporal orientation, being also the components with the highest growth compared to the others (Fernani et. al., 2013). Despite this, another important component found in several studies was the fine motor skill, which is responsible for the correct spelling of the letters and holding the handwriting tool. This is consistent with other research studies examining the link between fine motor skills, mathematics and reading skills in school-age children (Pienaar et al., 2014). For example, the same autor found that fine motor and visual skills are more strongly associated with math and writing than the total of motor skills. However, there was no qualitative difference between the 2, spatial ability and fine motor skill, therefore it is not known from studies which of them influences to a greater extent the process of writing, reading or calculating. Thus, the answer to the third question remains uncertain.

At the same time, the determining role of spatial skills in the process of writing and reading was identified, mainly due to the presence at the level of this structure of motor, psychomotor and psychological causes. This result is also consistent with other studies, which claim that if there are no physical causes, the predominant factor is the link between the motor skill and literacy (Capellini et al., 2010; Okuda and Capellini, 2011; Rochelle and Talcott, 2006; Rommelse et al.,

2009; Rosenblum et al., 2010). The temporal component was found only in terms of writing, not mathematical calculation in the revised studies. Thus, it was found that the poor mastery of spatial notions: up, down, before, left, right, may be one of the causes of the delay in learning to read, and mathematical writing and calculation. An important aspect is the identification of the spatial component as having a decisive role only in a certain part of mathematics, more precisely in geometry or graphical forms and not in mathematical calculus, which depends to a large extent on the ability to memorize, pay attention and only then the left-right orientation, up-down (Gilligan et al., 2017). This particularly interesting finding may indicate a positive role of early spatial skills on the processes of reading and math acquisition, which is consistent with the recognition of the second hypothesis, the one that highlights the impact that spatial orientation can have on writing, reading and calculation.

Strengths and limitations of the study

First, this review systematically summarized the findings of 20 studies, including a large sample of participants, aged between 5 and 15 years old (between 19 and 12,099 children), from different countries. Secondly, a comprehensive search of databases on all learning disabilities was carried out, in line with the Prisma guidelines, followed by a systematic screening approach to identify eligible studies. Thirdly, the search took place in 2 languages of international circulation (English and Spanish), which led to the maximization of the identification of suitable studies. Finally, this review allowed a deeper examination of the associations between the components of psychomotor skills and three of the fundamental learning skills (reading, writing and math), focusing on each and every one in an equal way compared to other researches, which addresses only one or just two components.

Even so, it is essential to recognize that there were some boundaries in this examination. Primarily, there has been a relatively small number of experimental studies (4), which may lead to an uncertain outcome and make motor intervention programs uncertain due to the limited number. Secondly, studies have focused on spatial skills rather than on temporal ones, which led to this component's relationship with writing and reading only, not with mathematics. Again, the result could be uncertain and uncertain, given that the association between the above was not paramount. Indeed, the search strategy was restricted to comprising studies that specifically examine the associations between the motor component and academic performance in writing, reading, and arithmetic. Nevertheless, it is clear that many covariates may as well have had an effect on the findings stated in the studies. These covariates included demographic factors, cognitive factors, and physical factors (body mass index,

fitness level). The third limitation is found in the identification of the main component of psychomotor skills that influence writing, reading and arithmetic disorders. Considering the included studies, it was not possible to highlight the primordiality between fine motor skill and spatial and temporal orientation, in terms of learning skills. Being two different components, oriented towards physical skills and mental skills, we can say that it is difficult to compare the two and clearly interpret the results.

Conclusions

Following the systematic review of the 20 researches, the first hypothesis was confirmed, finding that there is a link between psychomotor components and reading, reading and arithmetic disorders in children who are 5 to 15 years old. All children diagnosed with one of the learning deficits had a lower level of one or more components of motor skills. At the same time, following the motor intervention programs, all the children improved their motor skills, except for 4 of them, who remained at the same level.

The second hypothesis was also confirmed, identifying the impact that spatial and visual skills have on the literacy process, especially on geometric components. In addition to the spatial orientation, which correlated with all 3 domains, the temporal orientation was identified only for writing and reading. Thus, it was found that the poor mastery of spatial notions may be one of the causes of the delay in mastering reading, writing and mathematical calculation. Furthermore, the role of fine motor skills in the writing process was noticed, being of real importance when the child manipulates the writing tool and wants to put a word/sentence on the page.

Due to inconsistent or insufficient evidence supporting the associations of the other components of motor competence, further investigation is needed, using several experimental studies, focusing on several components, tested separately and not together. In order to further explore the influence of motor intervention programs on academic performance, it is essential to focus on the functions which contribute to the process of writing, reading and mathematical calculation, keeping in mind a possible effect of them, obtaining a clear possibility, that is to determine the impact that motor skills have on the academic performance.

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