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A LITERATURE REVIEW ON DEVELOPMENTAL DYSCALCULIA: EDUCATIONAL PERSPECTIVES FROM BRAZIL

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Abstract:
The educational environment plays a key role in human development, requiring structures that meet legislative demands as well as social needs arising from historical movements to recognize marginalized groups. Among these groups are students with dyscalculia, whose identification and appropriate support are essential for school inclusion. This bibliographic study aimed to analyze the main arguments regarding dyscalculia based on selected works. The most recurrent publications adopted a quasi-experimental approach (8 studies), followed by investigations with controlled groups, with or without matching (7), and literature reviews (7). Findings indicate that dyscalculia has a neurobiological origin, resulting in significant impairments in calculation, numerical manipulation, and the abstraction of mathematical concepts, associated with dysfunctions in neural áreas, especially the parietal lobe. Often confused with mathematical learning difficulties, dyscalculia is distinguished by the persistence of deficits even after interventions. This study highlights the need for further research on the subject to develop and implement effective tools for the various types of dyscalculia,

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contributing to more accurate diagnoses and appropriate pedagogical interventions, thus promoting inclusion and improved educational outcomes.

Keywords: dyscalculia; learning; calculations

1. Introduction

The educational environment is characterized as one of the key contributors to human development. It is based on the promotion of practical skills for the social and labor spheres (Brazil, 1996). In this sense, it requires a structure that supports and enables the provision of activities that address both legislative demands and the social demands that have emerged from historical movements recognizing groups whose voices were once silenced.

Among these groups are individuals with specific learning disorders, which, as neurobiological impairments, persist throughout life and whose effects can be observed from early ages. Such impairments typically affect the development of language and mathematics skills, with a prevalence ranging from five to fifteen percent. This percentage decreases in adulthood, suggesting the impact of interventions in mitigating these difficulties (American Psychiatric Association, 2014).

Developmental dyscalculia differs from other learning difficulties due to its etiology. Genetic markers of mathematical abilities, impairments in brain areas related to numerical processing, deficits in blood flow, and malformations in these neural networks lead to persistent challenges in solving logical, spatial, and mathematical problems (Cosenza & Guerra, 2011). Different brain regions are involved in these deficits, with particular emphasis on the parietal lobe (Haase, Wood, & Willmes, 2010).

Although the prevalence of dyscalculia is similar to that of dyslexia, its incidence is lower than that observed in cases of dyslexia (Haase *et al.*, 2010). In accordance with the provisions of Law No. 9.394 (Brazil, 1996), which already establishes the rights of these individuals and the obligations of the State to provide measures for their care, the recent enactment of Law No. 14.254 (Brazil, 2021) reinforces the need for discussion, promotion, and assurance of full education for students with specific learning disorders. Therefore, it is essential to examine the existing literature on dyscalculia in order to shed light on the presence of these students in classrooms. Furthermore, it is necessary to demand greater teacher training on these disorders and on the appropriate didactic-pedagogical interventions, in compliance with constitutional and legislative provisions for the comprehensive support of these students. In this context, the aim of the present study is to conduct a literature review, analyzing the main arguments concerning dyscalculia based on the selected works.

2. Material and Methods

At first, the research was conceived as a literature review with a qualitative approach (Creswell & Creswell, 2021). It was, therefore, a theoretical study in which the most frequent arguments found in the selected works were compiled to present synthesized discussions on dyscalculia. The search began with the Coordination for the Improvement of Higher Education Personnel (CAPES) portal, followed by the *Scientific Electronic Library Online* (SciELO), and finally, the *Latin American and Caribbean Literature in Health Sciences* (LILACS).

In these databases, the descriptors *"Discalculia"* and *"Discalculico"* were used, initially through a simple search with each descriptor independently, and subsequently through an advanced search combining both descriptors using the Boolean operator *AND* ("Discalculia" AND "Discalculico"). The inclusion criteria established were: (1) Studies published between 2000 and 2022; (2) Studies containing the descriptors "*discalculia*" and/or "*discalculico"* in the title, keywords, or abstract; (3) Studies written in Portuguese.

The exclusion criteria were: (1) Studies written in languages other than Portuguese; (2) Studies unrelated to the theme; (3) Studies that did not present the descriptors; (4) Duplicate studies, whether within the same database or across different databases.

Table 1 presents the entire search process in the three databases, which, after completion, resulted in 34 works selected for full-text reading.

Table 1: Cross-tabulation of the data from the literary Search

Descriptor: 'discalculia'					**Descriptors: 'discalculia' AND 'discalculo'**
Database	Found	After inclusion criteria	Excluded	Selected	
CAPES	150	59	33	26	0
SCIELO	29	5	4	1	0
LILACS	332	22	15	7	0
TOTAL	511	86	52	34 studies	0

Source: The author (2024)

After this initial process, an analysis of the selected studies was conducted in order to enter them into a spreadsheet using Microsoft Excel. The tabulation aimed to group the arguments presented in the articles that addressed the characterizations, concepts, typologies, definitions, and implications of dyscalculia (Abreu & Fontoura, 2011).

4. Results

The search in the databases began on December 20, 2022, and concluded on January 14, 2023. In the Coordination for the Improvement of Higher Education Personnel (CAPES) portal, the descriptor *"Discalculia"* was used, yielding 150 publications. After applying the inclusion criteria, 59 results remained. From these 59 documents, those meeting the exclusion criteria were removed.

In total, 33 studies were excluded: 25 were not written in Brazilian or European Portuguese, and 8 were duplicates within the same database. Consequently, 26 studies remained for in-depth reading. When using the descriptor *"Discalculico"* as a simple search, and the combination of the descriptors *"Discalculia"* AND *"Discalculico"* in the CAPES portal as an advanced search, 11 documents were retrieved. However, after applying the inclusion criteria, none were selected.

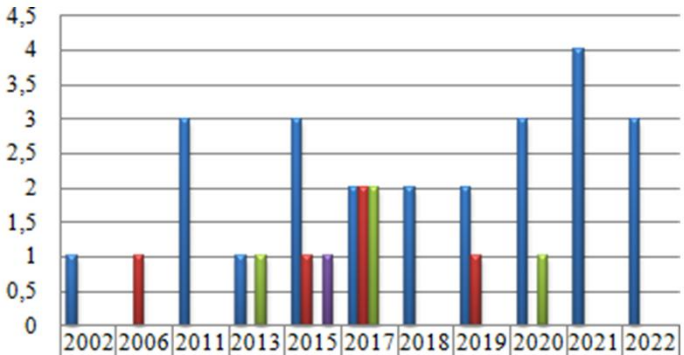
In the second stage, in the *Scientific Electronic Library Online* (SciELO), the search returned 29 documents when using the descriptor *"Discalculia"*. After filtering according to the inclusion criteria, 5 results remained. Of these, 4 were excluded due to duplication, as they had already been identified in the CAPES portal search. Thus, only 1 publication remained. Neither the simple search for the descriptor *"Discalculico"* nor the advanced search for *"Discalculia"* AND *"Discalculico"* yielded any results.

In the *Latin American and Caribbean Literature in Health Sciences* (LILACS) database, the search using the descriptor *"Discalculia"* resulted in 332 documents. After applying the inclusion criteria, 22 remained. Of these, 15 were excluded: 5 were inaccessible on their respective websites, and 10 were duplicates already identified in previous searches. The simple search for the descriptor *"Discalculico"* and the advanced search for *"Discalculia"* AND *"Discalculo"* yielded 1 document, which had already been identified. Therefore, 7 studies were selected.

As a result of this review, a total of 34 studies were selected for full-text reading. Dissertations and theses were examined primarily for their methods, results, discussions, and conclusions. Among these 34 publications, there were four (4) conference presentations, one (1) doctoral thesis, five (5) master's dissertations, and twenty-four (24) journal articles.

Regarding the annual distribution of publications, an apparent balance can be observed, as shown in Figure 1. The years 2002 and 2006 had the fewest publications, with only one each, while 2015 and 2017 had the highest numbers, with 5 and 6 publications, respectively. Overall, knowledge production on dyscalculia remains limited. The relatively low incidence of this disorder, compared to other neurodevelopmental and learning disorders, may serve as a possible explanation.

Figure 1: Number of publications per year



	2002	2006	2011	2013	2015	2017	2018	2019	2020	2021	2022
Article	1	0	3	1	3	2	2	2	3	4	3
Dissertation	0	1	0	0	1	2	0	1	0	0	0
Conference Proceedings	0	0	0	1	0	2	0	0	1	0	0
These	0	0	0	0	1	0	0	0	0	0	0

Source: The author (2024)

Theoretical works refer to those that describe a phenomenon based on a bibliographic analysis; literature reviews that explore a specific topic, whether systematic or not; quasi-experimental studies, in which results are derived from a single group without randomization, blinding, or a control/experimental group approach; experimental studies, which standardize study groups into control and experimental groups, matched; and case studies, in which the sample size (*n*) is small and results are explored in depth, presenting qualitative categories (Marconi & Lakatos, 2003).

The most frequent type of study was the quasi-experimental approach (n = 8), followed by those aiming to investigate a controlled group (n = 7), with or without matching, and literature reviews on dyscalculia (n = 7), respectively. Case studies were the least published, with only four. A plausible hypothesis for the greater number of experimental and review studies is the importance of understanding the ontology and etiology of dyscalculia.

5. Discussion

Among the 34 selected studies, twenty-one (21) referred to the neurobiological origin of dyscalculia. Two (2) studies argued for a sociocultural and historical construction of the disorder. One hundred and twenty (120) arguments elucidated the intrinsic characteristics of the impairments caused by dyscalculia. Twenty-two (22) addressed its extrinsic manifestations, noting similar deficits in mathematical problem-solving among individuals with the disorder. Eight (8) presented the different types of dyscalculia, each associated with specific cortical dysfunctions. Thirty (30) arguments discussed interventions and practices to be implemented.

It was evident that mathematics is among the subjects with the lowest and most concerning achievement rates. The multiple factors involved in assessing mathematical

performance further complicate the distinction between learning difficulties and learning disorders, as mathematical skills depend both on neural maturation and on the educational conditions provided to students (Molina *et al.*, 2015; Pimentel & Lara, 2017; Thiele & Lara, 2017).

Identifying and diagnosing dyscalculia is challenging, as mathematics-related difficulties may stem not only from dyscalculia but also from learning difficulties (LD) caused by environmental or exogenous factors, which can present the same signs. However, learning difficulties can generally be overcome, showing improvement after targeted training for the deficient skills. In contrast, dyscalculia persists despite specific interventions, which may alleviate the consequences of the disorder but do not eliminate it entirely (Avila & Lara, 2020; Cardoso, 2019; Thiele, 2017; Paz & Vargas, 2018).

In this context, the term "disorder" is reserved for impairments resulting from brain dysfunctions. Such dysfunctions can be detected through brain imaging and are reported in the selected studies, where reduced activity in the parietal lobe is observed during specific mathematical tasks. Individuals with dyscalculia show hypoactivation in specific regions of this cortex, presenting a pattern distinct from that of individuals with typical development. "Difficulties," on the other hand, are linked to multiple external causes (Cardoso, 2019; Pimentel, 2015; Silva *et al.*, 2015).

Case study and experimental research participants showed greater difficulty with subtraction and multiplication, due to rules that require the retrieval of multiplication tables, for example. However, the highest error rates were found in division tasks, partly because of borrowing procedures, which participants reported forgetting.

It is therefore important to clarify the role of memory in mathematical processing, as it is a cognitive function that contributes to the effective resolution of mathematical operations (Avila & Lara, 2017; Batista, Maia, & Silva, 2022; Cardoso, 2019; Pimentel, 2015; Silva & Santos, 2011; Thiele & Lara, 2017). Authors also place dyscalculia within the broader spectrum of developmental disorders, characterizing it as a specific deficit in mathematical skills with various cognitive impairments unrelated to intellectual disability or the educational system.

Marked by developmental brain dysfunctions and alterations in cerebral blood flow, dyscalculia is associated with impairments in the temporo-parietal and occipital areas. Although it is a specific condition, it can be subdivided into types, such as verbal, practognostic, lexical, graphical, ideognostic, and operational dyscalculia (Avila & Lara, 2021; Silva & Figueiredo, 2022; Silva, Ribeiro, & Santos, 2015).

Activities that may improve outcomes in dyscalculia involve external strategies, such as visual numerical manipulation and cognitive flexibility stimulation in the face of mathematical problems, since the least used strategies among participants were mental calculations and finger counting (Lara & Cardoso, 2021; Lara *et al.*, 2017; Gonçalves, 2015). Teachers should provide conditions conducive to student attention, using activities that stimulate multiple sensory pathways, such as specific math games, as well as those

involving psychoeducational, neuropsychological, and computational content (Avila, 2017; Bernardi & Stobaus, 2011; Fernandes *et al*., 2018; Siqueira & Gurgel-Giannetti, 2011). There is a need for further research on this topic, as there are few national publications on dyscalculia. This lack of dissemination can lead to limited teacher action due to a lack of awareness (Dias, Pereira, & Borsel, 2013), potentially contributing to the persistence of difficulties in students with dyscalculia (Matos & Santos, 2021; Pimentel, 2015; Silva & Figueiredo, 2022; Silva, Longhin, & Amaral, 2022). Nonetheless, the limited existing studies suggest that playful, case-specific practice-using games and music are promising for improving skills compromised by dyscalculia (Avila, Lara, & Lima, 2019; Brum & Lara, 2020; Guedes, Blanco, & Neto, 2019).

Neuroscientific interventions also play an important role. For example, studies evaluating school-aged children undergoing transcranial direct current stimulation (tDCS) in combination with conventional training specifically targeting the posterior parietal lobe reported positive outcomes for dyscalculia (Srivastav & Chatterjee, 2021). However, diagnosing this disorder remains challenging. The studies reviewed highlight that accurate diagnosis requires multidisciplinary practices, involving not only psychological or psychoeducational assessments but also school performance evaluations, brain imaging results, comprehensive anamnesis, responses to interventions, and standardized testing. This approach ensures that extrinsic factors, such as teaching methods rather than learning ability, are ruled out (Lara, 2020).

The literature reviewed shows an initial consensus on dyscalculia, emphasizing the need to consider self-referencing in publications as a methodological limitation. When an argument is repeated within the same study, it artificially increases its perceived validity, creating the impression of a solid hypothesis. In reality, the apparent weight of the argument is due to repetition, not to a large number of independent studies from different authors and contexts. This is a clear example of confirmation bias. Given the small number of studies, however, such repetition is inevitable in a literature review (Lara, 2020; Thiele *et al*., 2022).

6. Recommendations

This study presents some limitations that should be acknowledged. First, the review focused exclusively on publications in Portuguese, which may have restricted the scope of the analysis and excluded relevant contributions from the international literature. Second, the searches were conducted in a limited number of databases (CAPES, SciELO, and LILACS), which, although relevant to the national context, may not cover all existing studies on dyscalculia.

Another limitation concerns the reduced number of publications on dyscalculia in the Brazilian context, which restricted the breadth of comparisons and may have contributed to the recurrence of the same references in different works, increasing the potential for confirmation bias. In addition, the predominance of quasi-experimental

designs and literature reviews, combined with the scarcity of longitudinal or large-scale studies, may have limited the generalizability of the findings.

Finally, although the study sought to synthesize the most frequent arguments and approaches, the absence of standardized methodologies and the heterogeneous criteria among the selected works make it difficult to establish a unified understanding of dyscalculia in the Brazilian educational context. Future research should address these limitations by incorporating broader linguistic and database coverage, as well as more robust and diversified research designs.

7. Conclusion

Based on the data collected, it was found that research on dyscalculia at the national level remains scarce, consistent with the incidence of this disorder in educational settings. This scarcity may result in missed opportunities for early intervention, underreporting, lack of teacher preparedness due to insufficient robust information, and disinterest in discussing the topic due to limited data, among other factors. Nevertheless, there is evidence of an attempt to understand the phenomenon through experimentation, with eight quasi-experimental and seven experimental publications.

According to the analyses of the selected studies, dyscalculia presents neurobiological origins, significant impairments in skills involving calculation, number manipulation, and the abstraction of mathematical concepts, as well as dysfunctions in neural areas related to these impairments, particularly in the parietal lobe. It is often mistaken for general mathematical learning difficulties due to the low performance rates in national education. Furthermore, it was observed that the impairments caused by dyscalculia extend to memory, making it a component that should be targeted for stimulation.

It is understood that further research on dyscalculia is necessary so that effective tools can be developed and applied to reported cases and their subtypes. Although the number of publications is limited, the results of interventions involving games, music, visual numerical manipulation, cognitive flexibility, and manual or object-based strategies were frequently reported.

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Conflict of Interest Statement
The authors declare no conflicts of interest.

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