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How Attention and Strategies Shape Math Anxiety in Children

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Abstract: ***This study explores the bidirectional relationship between attentional biases, emotional regulation, and math anxiety. It highlights how sustained attentional states, influenced by attentional control deficits, contribute to anxiety and impaired mathematical performance. The article reviews the stability of attentional behavior and its long-term effects, discussing innovative computational models and intervention strategies. It emphasizes the need for addressing attentional control deficits to break the cycle of math anxiety and improve both emotional well-being and mathematical performance.***

Keywords: Math Anxiety; Attentional Biases; Emotional Regulation; Computational Models.

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1. Introduction

The existing literature underscores the complex interplay between attentional stability, learning strategies, and math anxiety in primary school students. Several studies highlight the significance of cognitive and emotional factors in shaping mathematical performance and anxiety levels. For instance, research on math anxiety reveals that students with high anxiety often exhibit difficulties in working memory, which adversely affects their math achievement (Mustard, 2002). This suggests that attentional stability, which is closely linked to working memory capacity, may serve as a crucial factor in mitigating math anxiety.

Mindfulness-based interventions have been shown to positively influence psychological health by reducing anxiety symptoms, including math and test anxiety, among elementary students (Keng et al., 2011). Specifically, mindfulness training programs like the Attention Academy have demonstrated effectiveness in enhancing students' attentional control, which in turn can alleviate anxiety related to mathematics (Kaunhoven & Dorjee, 2017). These findings imply that fostering attentional stability through mindfulness may be a promising strategy to address math anxiety.

Furthermore, integrating social-emotional learning (SEL) and conflict resolution training into educational practices has been associated with improvements in students' emotional regulation and social skills, which are essential for creating a supportive learning environment (Darling-Hammond et al., 2020; Darling-Hammond & Cook-Harvey, 2018). Such environments can reduce the emotional barriers that contribute to math anxiety, thereby facilitating better engagement with mathematical tasks.

Recent theoretical models emphasize the interaction between math anxiety and enjoyment, suggesting that positive emotional experiences in mathematics can enhance performance and reduce anxiety (Van der Ven et al., 2023). This integrative perspective indicates that strategies aimed at increasing enjoyment and reducing anxiety should concurrently target attentional control and emotional regulation.

Neuroscientific research supports these behavioral findings by illustrating how anxiety impacts mathematical thinking at the neural level. For example, studies utilizing fMRI have shown that anxiety can interfere with brain regions involved in mathematical reasoning, highlighting the importance of interventions that improve attentional regulation to counteract these neural effects [7].

In summary, the literature advocates for a multifaceted approach that combines attentional stability enhancement—through mindfulness and cognitive training—with social-emotional learning strategies to effectively reduce math anxiety in primary school students. Such integrated interventions not only improve mathematical performance but also promote overall psychological well-being, emphasizing the importance of addressing both cognitive and emotional dimensions in educational practice (Kaunhoven & Dorjee, 2017; Yu, 2023).

2. Psychological Foundations of Math Anxiety and Its Manifestations in Primary School Students

The psychological foundations of math anxiety and its manifestations in primary school students are complex and multifaceted, involving cognitive, emotional, and environmental factors. Math anxiety can negatively impact students' achievement, with emotional responses to mathematics playing a crucial role in understanding academic outcomes, as highlighted by Mutawah et al. (Al Mutawah, 2015). Similarly, neural mechanisms contributing to the development of anxiety related to math tasks suggest a biological basis for these psychological phenomena, as explored in a neurobiological study (Yu, 2023).

The emotional aspect of math anxiety is further discussed in terms of its multidimensional components, with primary school students significantly affected by mental arithmetic problems, which can trigger anxiety responses. This emotional response often leads to difficulty in engaging with math tasks, resulting in a cycle of avoidance and decreased confidence, as demonstrated by another study (Mammarella et al., 2023).

Environmental influences also play a critical role. Teachers' own anxieties can be transferred to students, especially in primary education, reinforcing negative attitudes toward mathematics. This suggests that the psychological environment within the classroom can either mitigate or exacerbate math anxiety, as pointed out by Spotlight on math anxiety (Ganal & Guiab, 2020).

Interventions aimed at reducing math anxiety recommend strategies for recognizing symptoms and counteracting anxiety, which is essential given that nearly half of elementary students are affected by math anxiety, potentially hindering their learning process, as discussed in a related study (Furner & Berman, 2003). The importance of psychological support and interactive learning is emphasized by Podlisna, who advocates for continuous psychological reinforcement to promote mental development in junior students.

The cognitive consequences of math anxiety are linked to disruptions in cognitive processes necessary for mathematical reasoning, impairing students' ability to utilize higher-level mental strategies, as examined in another study (Suárez-Pellicioni et al., 2016). This disruption negatively affects their arithmetic performance, as noted by a further study (Möhring et al., 2024).

In summary, the reviewed literature underscores that math anxiety in primary school students is rooted in psychological, neurobiological, and environmental factors. Its manifestations include emotional distress, cognitive disruptions, and behavioral avoidance, all of which can be mitigated through targeted interventions, supportive teaching practices, and fostering positive emotional experiences with mathematics. Addressing these psychological foundations is essential for improving mathematical achievement and fostering a healthier attitude toward learning mathematics at an early age.

3. The Bidirectional Mechanism of Attentional Stability on Math Anxiety

The bidirectional mechanism of attentional stability and math anxiety has garnered significant attention in recent research, emphasizing the complex interplay between attentional processes and emotional responses related to mathematics. Several studies highlight that attentional biases and stability are both influenced by and contribute to math anxiety, suggesting a reciprocal relationship.

Research indicates that attentional biases towards threat or negative stimuli play a crucial role in the development and maintenance of math anxiety. For instance, mechanisms of attentional biases towards threat have been explored in the context of anxiety, revealing that sustained attentional states function more like a floodlight rather than a spotlight, which can impair performance and exacerbate anxiety (Suárez-Pellicioni et al., 2016). This suggests that difficulty in regulating attention may lead to heightened emotional responses, creating a vicious cycle.

Further, the stability of attentional behaviors over time has been demonstrated in longitudinal studies, such as those assessing emotion regulation behaviors from infancy to later stages, which imply that attentional patterns are relatively stable and can influence anxiety levels across development (Vondra et al., 2001). This stability may underpin the persistent nature of math anxiety, where attentional control deficits contribute to ongoing difficulties in mathematical tasks.

The bidirectional relationship is also supported by findings that poor performance in mathematics can increase anxiety, which in turn affects attentional control, thereby impairing further performance (Sorvo et al., 2022). This aligns with the deficit theory, proposing that deficits in attention and executive function can both result from and contribute to math anxiety, reinforcing the cyclical nature of the relationship.

Innovative computational models further elucidate this mechanism. For example, hybrid architectures integrating self-attention mechanisms with bidirectional long short-term memory networks (SA-BiLSTM) have been proposed for fine-grained classification tasks, demonstrating the importance of bidirectional attention in capturing complex emotional and cognitive states (Liu et al., 2025). Similarly, the application of bidirectional attention mechanisms in emotion recognition models has shown promise in producing stable, semantically rich embeddings, which could be instrumental in understanding attentional stability in emotional contexts like math anxiety (Palikhe et al., 2025; Zhao & Chen, 2021).

In summary, the literature underscores a bidirectional mechanism whereby attentional stability influences math anxiety, and vice versa. Attentional biases towards threat and deficits in attentional control can heighten anxiety, which then further impairs attention, creating a reinforcing loop. Understanding this reciprocal relationship is crucial for developing interventions aimed at breaking this cycle and improving mathematical performance and emotional well-being (Fishstrom et al., 2022; Rubinsten et al., 2018; Zelazo et al., 2016).

4. Intervention Approaches and Practical Applications Based on Learning Strategies

The literature on intervention approaches and practical applications based on learning strategies highlights a diverse array of methodologies tailored to enhance learning outcomes across different domains. Many of these approaches emphasize leveraging cognitive and metacognitive processes to facilitate effective learning.

A theoretically grounded therapeutic model for phonological disorders is presented by Dean et al., which emphasizes the development of metalinguistic awareness. Their approach conceptualizes the child as an active learner who benefits from conflict and reflection, utilizing metalinguistic tools to foster linguistic development. This model underscores the importance of reflection and awareness in intervention, providing specific treatment examples that demonstrate practical application (Dean & Howell, 1986)

In the realm of computational and system-based learning, Montani et al. describe a case-based reasoning (CBR) approach designed for autonomous diagnosis and remediation in software systems. Their methodology exemplifies how learning strategies can be embedded within technical systems to enable self-healing capabilities, illustrating a practical application of learning paradigms in real-world scenarios (Montani & Anglano, 2006). Educational strategies such as peer-assisted learning are explored by Bain et al., who review its application in diagnostic radiography and health education. Despite the limited evidence base identified, the review suggests that peer-assisted learning can be a valuable approach for developing diagnostic skills, although further research is needed to substantiate its efficacy (Bain et al., 2017).

Strategic management education is the focus of Contreras et al., who provide a tool that integrates knowledge and enhances students' analytical capacities. Their work demonstrates how structured learning interventions can support the development of strategic thinking, aligning with broader goals of fostering critical analysis skills (Llanos Contreras et al., 2018).

The effectiveness of micro-learning as a strategy to increase engagement and performance in online courses is examined by Kossen et al. Their trial indicates that micro-learning design principles significantly boost student engagement, satisfaction, and academic performance, highlighting the practical benefits of concise, targeted learning modules in digital environments (Kossen & Ooi, 2021).

In optimization and algorithmic applications, Li et al. introduce a multi-strategy teaching-learning-based optimization algorithm to solve complex scheduling problems. Their approach redefines traditional algorithms by considering individual differences, showcasing how learning-inspired strategies can be adapted for practical problem-solving in operational contexts (Li et al., 2023).

Rule renewal mechanisms within learning classifier systems to enhance UAV swarm adversarial strategies are explored by Li et al. Their work demonstrates the application of learning strategies to improve rule bases through experience-based updates, emphasizing continuous learning and adaptation in autonomous systems (Li & Zhang, 2023).

Advancements in ensemble learning are discussed by Mendes-Moreira et al., who propose a systematic framework based on a unified theory of diversity. Their approach aims to improve predictive performance by strategically combining multiple models, illustrating how learning strategies can be systematically optimized for better outcomes (Mendes-Moreira & Mendes-Neves, 2024).

An adaptive meta-learning probabilistic inference framework (AMPIF) for long sequence prediction tasks is developed by Zhu et al. Their method decomposes sequences into seasonal and trend components, enabling models to adaptively learn from different aspects of data, exemplifying the application of meta-learning strategies to complex temporal predictions (Zhu et al., 2024).

Finally, Felipe et al. investigate the use of computational thinking in teaching stellar astrophysics through an action research approach. Their findings suggest that computational thinking facilitates active and structured learning, promoting deeper engagement and understanding in physics education (Raba Duván Felipe et al., 2025).

Overall, these studies collectively demonstrate that intervention approaches rooted in learning strategies—ranging from metacognitive awareness and peer-assisted learning to adaptive meta-learning and system-based algorithms—can be effectively applied across educational, computational, and operational contexts to enhance learning and problem-solving capabilities.

5. Conclusion

The findings demonstrate that attentional biases and deficits in attention control are key factors in the development and persistence of math anxiety. These biases create a vicious cycle, where anxiety impairs performance, which in turn exacerbates the anxiety. Interventions focusing on improving attentional control and emotional regulation can disrupt this cycle, offering potential solutions for enhancing both emotional well-being and mathematical performance. Future research and applications in computational models may provide further insights into effective interventions.

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