International Journal of Social Science Archives

ISSN: 2707-8892

Available at www.ijssa.com

International Journal of Social Science Archives, Jan-March, 2024, 7(1), 173 - 185

Analyzing Math Anxiety and Math Performance Relationship under Various Theories at School Level

Muhammad Sajjad[a*], Dr. Bushra Naz[b], Dr. Munwar Bagum[c]

[a]PhD Scholar, Department of Applied Psychology, Islamia University of Bahawalpur. [b]Lecturer, Department of Education, GC Women University Faisalabad, Punjab, Pakistan. [c]Assistant Professor Department of Education, Institute of Southern Punjab, Multan, Pakistan.

[*]**Email:** sajjad198712@gmail.com

***Abstract*:** Mathematics is an important subject at all educational level. It is considered as one of the key subjects in most of the fields of study. However, Mathematics is a cause of anxiety for many students studying at different educational level. Math anxiety (MA) is considered as the sign of poor performance in Mathematics. The objective of this review study was to analyze Math anxiety (MA) and Math performance (MP) relationship under various factors and theories at school level. To conduct the review, a total of 63 full-text articles were selected from different databases by ensuring the inclusion and exclusion criteria. The studies reviewed indicated that MA and MP mostly depend on the complexity of mathematical assignments and dimensions of MA. MA evaluated with affective and cognitive dimensions under various theories indicated a negative impact on MP. The results also indicated that when MA is associated with complex mathematics problems that require numerous steps to solve indicated a higher degree of math anxiety.

Key Words: School, Impacts, Math Anxiety, Theories, Math Performance

1. Introduction

Math anxiety (MA) describes the worry, stress, and trepidation that many individuals feel while working with numbers. MA differs from both state and test anxiety regarded as trait-level anxiety. Math causes more than just hate or fear in a math worried student; it influences biologically such as brain activity, cortisol levels, and heart rate. Conspicuously, the students that are more anxious to math had faster heart rates and, when cued with an upcoming arithmetic exercise, displayed brain activations akin to those seen in people who are in pain. MA has also been linked to phobias since the brief experience with mathematics stimuli induces a behavioral disconnection bias comparable to a fear-conditioned inducement. High levels of MA is associated with low math performance (MP), demonstrating an obstructive in academic achievement (Silver et al., 2021).

MA has been linked to poor mathematics performance (MP). It has remained a source of worry in education, and it relates to the condition of tension, fear, and uncertainty that students face when they engage in mathematics. According to several studies, this fact is a major issue among students from primary to higher education levels. MA leads to poor performance when a student wants to solve a math issue or deals with math concept. Furthermore,

previous research studies suggested that students with more MA have little interest in mathematics, are less driven and confident in the subject of mathematics, and avoid attending math classes in school. It has long-lasting implications for higher studies and career selection, such as not taking STEM education at a higher level, not acquiring higher education, and choosing such profession that has no mathematics skills application (Casanova et al., 2021).

There is a great concern of MA with cognitive process. When an individual solves a mathematical problem, the cognitive information process starts to work. MA has a detrimental impact on Math performance by altering working memory sources. Working memory (WM) is conceived of as a restricted supply of cognitive processes in charge of the temporary processing and storage of information in momentary awareness. Individuals with a high level of MA has shorter working memory (WM) spans, particularly when tested with computationally-oriented work. When combined with memory load work, this lowered WM capacity resulted in a considerable rise in mistakes. WM capacity has been demonstrated to be a reliable predictor of mathematics problem solving and solution approaches in several investigations (Chen, 2019). The influence of MA on WM is shown in figure 1.

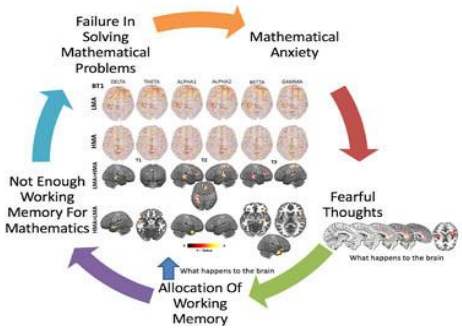

Fig.1: Influence of MA on Working Memory (Klados et al., 2019)

1.2 Statement of the Problem

As math is a tool that can be used to answer issues in every other field so, it is regarded as the mother of all sciences. There is a direct or indirect relationship of mathematics with all the fields of study. At a school level, it is one of the core subject that has to learn by all the learners. A student that has the ability to solve the mathematical problems achieve high performance in academic and practical life. On the other hand, a student that feels troubles in solving the mathematical problems will result poor academic performance and may face difficulties in his/her practical life. A student that has anxiety in Mathematics learning fails to develop his/her cognitive development. Hence, there may exist a close relationship between the math anxiety and math performance. So, it is need of time to find what is the relationship between math anxiety and math performance by considering various factors and theories at school level.

1.3 Objectives of the Study

The objectives of the current state of the art investigation were:

- **i.** To explore systematically the MA and MP relationship under various factors and theories at the school level
- **ii.** To discuss the factors that affect MA and MP relationship and
- **iii.** To mitigate MA under various theories, interventions, and factors.

1.4 Research Questions

1. What is the relationship between MA and MP?
2. What are the factors that affect the relationship between MA and MP?
3. What are the main theories involved in MA and MP?

4. How to alleviate the MA?

3. Research Methodology

3.1 Article Selection Process

The Prisma diagram was followed for the selection of the articles. Its procedure is discussed in the following lines:

3.1.1 Identification

3.1.1.1 Databases and Time Limit for Literature Search

The researchers searched the articles on the Math anxiety and Math performance form June 2015 to December 2023 from the major electronic databases including ERIC, Web of Science, Google Scholar and Scopus. The key terms used for literature search for articles were: Math anxiety, Math performance, and link between MA and MP.

3.1.1.2 Inclusion Criteria for Literature

The articles were included based on the following criteria:

- Only those articles were included that reported the link between the MA and MP at primary or secondary level. For example, study of Foley et al. (2017) clearly stated the link between MA and MP. The studies that have no link between MA and MP were excluded.
- The studies that were published in a peer reviewed journal, from the year 2015 to 2021 and written in English were included in the study. The studies that did not meet this criterion were excluded.
- Only those studies were included that investigated the link between MA and MP in the light of various theories developed to justify the relationship between MA and MP. For example, the study of Zhang et al. (2019) that investigated the link between MA and MP under various theories was included. The articles that did not fulfill that criteria were not included.

So, initially 1325 studies were identified.

3.1.2 Screening

After removing the duplicate records of 397 studies, the remaining studies were 928 based on inclusion and exclusion criteria. Records excluded on the basis of the abstract review were n=276, not relevant n=209, and not in English n=9.

3.1.3 Eligibility

The total full-text articles assessed for eligibility obtained were n=434. The full-text articles that have no link between MA and MP were also excluded n=276. Also, the articles that have no involvement of theories for the investigation of link between MA and MP were excluded. That were 95 studies not involving any theory.

3.1.4 Included

So, the final studies included in the review were obtained as n=63. The article selection process followed by the Prisma diagram is shown in figure 2.

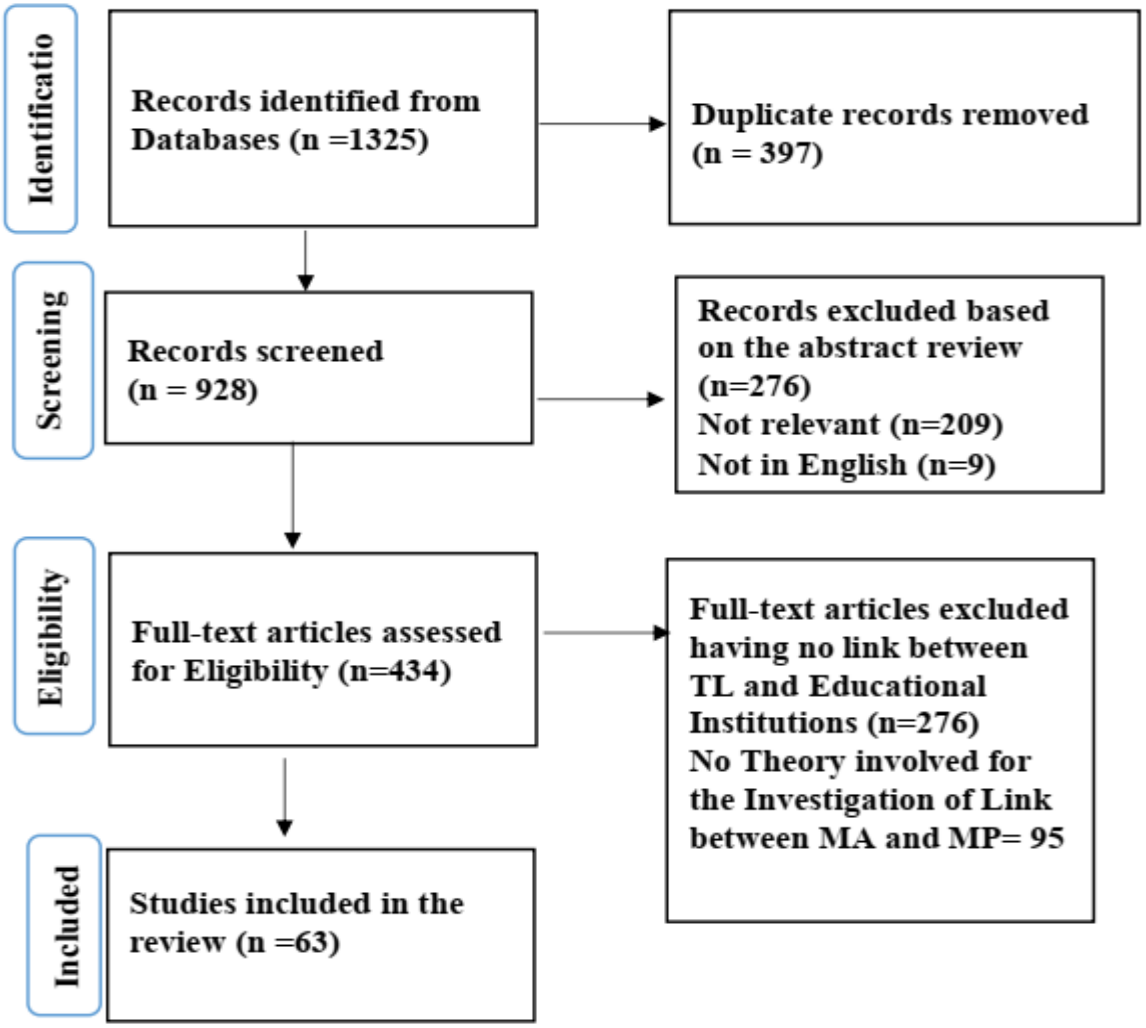

Fig. 2: Prisma Diagram for the Article Selection Process

4.1 Results

The results of this study were formulated according to the research questions as:

RQ1: What is the relationship between MA and MP?

One of the most convincing discoveries in the field of MA research is the linkage between MA and MP. To explain the relationship between MA and MP, two frameworks have been presented in the literature. The first one is Disruption Account (DA) and other framework is based on the Reduced Competency Account (RCA), which claims that MA is a proxy for weak mathematical aptitude. Following that, the researchers looked at the evidence for these two frameworks:

1. Disruption Account (DA)

The most commonly accepted explanation holds that MA impairs MP by causing a temporary decrease in the cognitive resources required for achievement in mathematics like working memory (WM). The WM is a type of short-term memory that manages, regulates, and actively maintains a small quantity of information relevant to the task at hand. When practicing math, individuals use WM to retrieve information required to answer a math issue, keep critical evidence about the problem prominent, and suppress extraneous information. Invasive views and cogitations, on the other hand, can cause WM to be disrupted. MA is supposed to be the result of negative views and cogitations, usually regarding the implications of failing a math task. As a result, when an individual with higher MA engages in math usually performing 2 tasks at a time: (a) dealing with unpleasant ruminations and views

and (b) trying to tackle the current math difficulties. Because math achievement is so frequently reliant on WM properties, it has been suggested that the online load of affective issues hinders WM, which in turn reduces an individual's capability to resolve mathematics tasks successfully (Samuel & Warner, 2021).

The link between MA and MP is due to anxieties interfering with crucial WM resources rather than math skills. Research studies examining variations in fundamental mathematics skills between individuals with low and high MA supports DA of MA. Individuals with more MA are leisurely and make more mistakes while doing fundamental mathematical tasks, but only for situations that demand a carry operation, which is recognized to place significant stress on WM (Pizzie et al., 2020). Pletzer et al. (2015) revealed neurological data compatible with a DA in research that found a variance in brain efficacy between students with low and high MA.

WM is an imperative moderator that links MA and MP. The previous studies investigated the relationship between individual variations in MA and WM and students' performance on a standardized math achievement test. Even though high WM students would be expected to be the least affected by MA since they have more of this crucial cognitive resource, the outcomes indicated that these pupils might be the most vulnerable to the influence of MA. As a whole, these findings supported the DA in which MA has an influence on performance by eliciting adverse views and cogitations that co-opt the WM resources needed to solve arithmetic problems (Passolunghi et al., 2020). As a result, according to a DA, MA is linked to reduced success since it produces adverse arithmetic performance and skills.

1. Reduced Competency Account (RCA)

The DA of MA is the most common explanation for how MA affects arithmetic accomplishment, and it also supports the RCA, which claims that MA is the result of inadequate math aptitude. According to RCA, a pupil's lack of competence leads to poor learning and performance, which subsequently contributes to MA. As a result, MA is a result of inadequate math skills. Variations in the RCA have been presented as explanations for both the performance relationship between MA and why people develop MA in the first place. Under RCA, models have been proposed to explain how weaker abilities may connect to MA (Wang, 2020).

Maloney and his colleagues presented the first framework, which was stated as the Spatial Difficulties Framework (SDF). Persons begin with weaker spatial capabilities in this paradigm, and in a conclusion, they underachieve in mathematics. People feel nervous as a consequence of their underperformance. Reduced skills may generate MA (Maloney, 2016). A series of researchers found that the individuals having higher level of MA were leisurely to accomplish simple arithmetical and spatial tasks, such as counting items, supporting the SDF, selecting the greater of two single numbers numerically, or envisioning what a three-dimensional item might look like if it were alternated (Liu et al., 2019).

Another paradigm offered under the RCA framework that students with limited mathematics capabilities avoid attending mathematics classes and take advantage of opportunities to improve their math skills. Students may fall farther behind in their arithmetic comprehension as a result of this avoidance, which can lead to MA. Students who have MA attend fewer math classes, which supports this framework, and MA has long been linked to adolescent students' unwillingness to pursue math classes. Furthermore, engagement in non-school arithmetic activities has been connected to children's math achievement, it is also likely that individuals who are anxious about math would shun informal math experiences (Thompson et al., 2017).

2. Comparing DA and RCA

The DA contends that MA leads to adverse MP by reducing essential WM resources, whereas the RCA contends that poor MP leads to MA. As a result, the DA would point to the elimination of anxieties as a guideline in the creation of remedies to alleviate MA. The RCA predicts that removing anxieties would not alleviate performance challenges, because math-anxious persons still lack the requisite mathematics abilities, particularly when faced with increasingly complex math. These two points of view offer quite different recommendations for developing remedial procedures for lowering MA and the potential consequences of MA (Bjälkebring, 2019).

It is vital to highlight that these two types of theories are not mutually exclusive. The RCA is unsure if MA results in adverse views and cogitations that impair performance. Even though the researchers have considered these two main perspectives as being rather opposed, current research reveals that the relationship between MA and MP is

most likely bidirectional. Both the DA and the RCA are supported by results from research that uses functional magnetic resonance imaging (fMRI) to evaluate changes in brain stimulation between lower and higher math-anxious pupils performing mathematics activities. For example, Young et al. (2012) studied children aged 7 to 9 who were assigned tasks with determining whether resolved arithmetic problems (subtraction and addition) were accurate or wrong. Throughout the study, higher mathematical-anxious pupils indicated more activity in brain areas linked with processing adverse feelings and terrifying stimuli, and less activity in brain regions related to WM. Furthermore, higher-math-anxious youngsters had lower activity in posterior parietal brain areas considered to be important in mathematical and numerical reasoning. MA is both a cause and a result of adverse arithmetic capabilities, as evidenced by the activation of both numerical processing regions and cognitive control in mathematical-anxious students. Both DA and RCA are supported by these findings.

RQ2: What are the factors that affect the relationship between MA and MP?

The most important factors that affect the relationship between MA and MP are listed as:

1. Gender

Gender may have an impact on the math anxiety-performance link. Several studies have found that females have much higher MA than males. For example, Maloney and Beilock (2012) speculated that female students have a higher degree of MA than male students when doing a task that requires mathematical skills. Some studies also indicated that females have higher MA than males; however, they did not have a greater level of MA than males during a math content test (Levy et al., 2021).

2. Grade Level

MA is thought to have an effect on MP over time. MA may develop as the trouble of math learning rises with oldness. According to recent research studies, there is a detrimental correlation between MA and MP among students. However, for the elementary students, the association between MA and MP remained ambiguous. Some studies showed that the MA of primary school students had little bearing on their performance (Kucian et al., 2018) whereas, other researchers have shown that the association between MA and MP persisted even at this stage of age (Wu et al., 2017). According to these findings, grade level may affect the MA performance connection.

3. Geographical Region

Previous research studies have suggested that the link between MA and MP may be influenced by geographic location. Wu et al. (2017) concluded in their studies that the adverse MA performance was higher in China than in the USA. Academic accomplishment is highly prized in Asia, which contributes to Asian students' high levels of MA. In contrast, students in European nations appear to be less judgmental of their academic achievement and more easygoing. Several types of research comparing one or two nations looked into this link (Baten et al., 2019). However, no consistent results were discovered, making it impossible to assert a universal pattern of this connection across nations. As a result, more information about how cross-cultural knowledge influenced this unfavorable link is required.

4. Difficulty of Mathematical Tasks and Working Memory

According to the cognitive interference theory, WM might perform a critical role in the underlying link between MA and MP. WM is a finite cognitive resource that allows you to retain knowledge while also working on or changing it. WM's involvement in mathematics competency has been thoroughly researched, with several studies indicating a strong link between WM and many forms of mathematical ability. Anxiety-induced cognitions, such as invasive views and fears, generate a scenario where individuals have to do two things at once, in which pupils, in addition to tackling the Math's challenge at hand, must deal with their negative cognition. This would eliminate the need for restricted WM, resulting in longer retort times and a higher level of rates, as well as decreased processing efficiency and MP (Orbach et al., 2019).

In a similar vein, the complexity of mathematical activities may have a distinct impact on the MA and MP relationship. More challenging activities, in addition to MA, may stress cognitive resources and, as a result, have a

bigger detrimental impact on MP. Vukovic et al. (2013) discovered that MA did not have the same impact on different forms of MP. Children's computation and mathematical application skills were predicted by MA, but not geometric reasoning. According to the researchers, geometry in early classes may not be tough enough to elicit MA. Compared to easy arithmetic tasks, complex mathematics issues requiring more cognitive processing provoked a higher degree of MA among grade 2 and 3 students with good WM capacity (Ching, 2017). Both research results demonstrated that the relationship between MA and MP might vary depending on the difficulty of the mathematical tasks. As a result, research reveals that the impact of MA on MP may vary depending on the difficulty of the mathematical tasks.

RQ3: What are the main theories involved in MA and MP link?

1. Theories Involved in MA and MP

It is very important to understand the link between MA and MP for intervention not just conceptually, but also practically. In this case, if poor MP causes MA, intervention energies must concentrate on refining mathematical abilities and skills. Contrary, if MA is the cause of low MP, intervention energies must be focused on reducing MA and therefore boosting MP. Several competing theories exist about the association of MA and MP, including deficit theory, cognitive interference theory, and reciprocal theory (Namkung et al.,2019). These theories are discussed in detail in the following lines:

2. Deficit Theory

The deficit theory states that poor MP memory of poor MP results in greater MA in future studies. The majority of evidence in favor of the deficit theory comes from longitudinal research on children with mathematical learning restrictions. In numerous studies supporting deficit theory, children with mathematical challenges stated abnormally high degree of MA when related to their usually successful colleagues (Passolunghi et al., 2016). Moreover, Ma and Xu (2004) studied 6-year longitudinal information from secondary and higher secondary school's pupils using cross-lagged structural equation modeling to explore the causative direction of the association between MA and MP. The authors concluded that past poor MP was strongly and adversely connected with later MA, whereas prior MA was not remarkably associated with subsequent low MP, indicating that the deficit theory is well supported.

3. Cognitive Interference Theory or Debilitation Anxiety Model

The cognitive interference theory or debilitation anxiety model states that MA influences later MP. The interference mechanism presents itself in 3 ways: during information pretreatment, processing, and retrieval. MA helps pupils to avoid mathematics-related circumstances during pre-information processing. Previous research studies like Hembree (1990) combination, has shed light on how MA might contribute to poor MP at the pre-information processing stage. The students not only dislike mathematics at the school level due to MA but are also, confused and avoid taking mathematics as a subject at a higher educational level. This would result in fewer opportunities for mathematics learning resulted inferior mathematics achievement. Another process that can underpin the cognitive interference theory is strongly connected to WM theories. MA impacts MP by causing a cognitive distraction during information processing and retention. Worries and intrusive thoughts produced by MA might deplete WM resources that would be allocated to perform arithmetic problems, severely impacting MP. MA intervention studies provide the final piece of proof. Intervention trials that did not include any mathematical components but focused on reducing MA have concluded in increased MP (1990). This conclusion supports the cognitive interference explanation by indicating that MA, rather than inherent mathematical skills impairments, may be the cause of poor MP.

4. Bidirectional Theory

Several research studies have shown that there is a bidirectional association between MA and MP. Luo et al. (2014) discovered that prior MP influences students' MA, which disturbs future MP by selecting a sample of pupils from a secondary level school in Singapore. With younger students, the results were also similar: e.g., Cargnelutti et al. (2017) discovered that impacts of MP on MA were greater for class 2 and that MA for class 2 had substantial

indirect impacts on future MP. The benefits of an MA on MP were highest for class 3. Poor MP promotes MA, which then negatively disturbs MP in a brutal cycle.

RQ4: How can We Alleviate MA?

The widespread adverse association between MA and MP joined with evidence that MA can restrict to cognitive resources required for mathematics, highlights the significance of inscribing MA to advance MP more broadly and STEM success. Attempts to reduce MA must contain both strategies to cure people who currently have it and measures to prevent it from occurring in the first place. Lab researches show that psychological strategies stressing self-control, emotional management, and a rethinking of physiological risk responses have the potential for treating math anxiety. This strategy may aid children with high math anxiety, which is a theory that may be examined in a forthcoming study. Moreover, treatments might be designed to provisionally lower pupils' math anxiety at a period when it is the most dangerous to their concert, such as before the examination. Park et al. (2014) observed that letting students write regarding their views and spirits before taking a mathematical exam minimized the performance disparity between persons with low and high MA. Instead of attempting to eliminate many students' strong physiological reactions to arithmetic, it may be more beneficial to participate in the reassessment of these emotive replies, or simply to reframe the physical response.

When instructors and parents know how their concern impacts the student's MP might give insight into the best approach to avoid MP from being passed down the generations. Students who are afraid of math have adverse attitudes toward mathematics. When mathematical anxious instructors and parents interact with children in mathematical-related situations, like assisting with pupil's math home task, their adverse effects and behavior may restrict the capability to efficiently communicate about mathematics, negatively impacting pupils' mathematics-related learning and success. The instruments that influence mathematical-anxious and instructors' and parents' communications with children around mathematics may have a positive impact on students' math success, even if they don't decrease the parents' arithmetic worry. Berkowitz et al. (2015) discovered that Bedtime Math, an arithmetic iOS app that helps fathers and mothers through reading an everyday text and doing associated math problems with their 1-grade students, dramatically improved the mathematics grades of pupils whose parents were mathematics-averse. Furthermore, a current neuroimaging research discovered that high MA three-class students who got rigorous one-on-one coaching exhibited a substantial decrease in amygdaloidal nucleus activity when completing arithmetic, which was linked reduce in the degree of MA (Passolunghi et al., 2020). Following that, the researchers go over some of the most effective methods for reducing MA or reducing its negative effect on accomplishment.

1. Interventions for Math Skills and Exposure

According to RCA, improving mathematics skills through interventions may also be beneficial in dropping MA. Supekar et al. (2015) found that a concentrated eight-week one-on-one cognitive coaching program for youngsters lowers arithmetic anxiety. The researchers discovered that similar to phobia therapies, exposure to arithmetic might not only increase arithmetic abilities but also decrease MA by desensitization. The students underwent fMRI examinations before the intervention, which revealed that greater math-anxious kids showed abnormal brain answers and connections in feelings-related circuits concentrated in the amygdaloidal nucleus when practicing arithmetic. Follow-up MRI examinations revealed that these abnormal neural replies vanished following the 8-week intervention, there were no variations in brain activity between children who were more or less anxious about arithmetic.

2. Interventions and Interpretation

The interpretation account demonstrates the significance of assessment procedures in determining not just who advances in MA, but also whether mathematics-anxious pupils stumble or succeed in difficult arithmetic settings. Games and interactive platforms may inspire students to become more engaged with math and to regard it as pleasurable. Students may be unable to persevere in arithmetic if they see difficulties as a result of their incompetence rather than a normal part of the educational learning process. Students must realize that math isn't

always enjoyable, but that there's a lot to be gained through effectively striving and engaging in mathematical reasoning processes (Hart & Ganley, 2019). Indeed, research suggests that rather than repressing anxieties or avoiding arithmetic, encouraging people to reconsider their math phobia or accepting the idea that disfluent learning might be beneficial is one of the most viable options for remediation.

3. Physiological Arousal Interpretation

When learners are confronted with difficult academic conditions, many of them transcend their emotive reaction by perceiving the issue as an encounter to be overwhelmed rather than a risk to be avoided. The biopsychosocial threat and challenge model describes such an explanation effectively, arguing that circumstantial demands might be rated as dangerous when students assess that they lack the individual resources to adequately meet those demands (Pizzie & Kraemer, 2021). On the other hand, persons who believe they have the individual resources to satisfy the circumstantial expectations are extra inclined to regard such needs as an encounter that aids achievement.

Reappraisal studies have recently been expanded to include MA. Jamieson et al. (2016) investigated the merits of reassessment among college pupils taking a remedial arithmetic topic. One set of contributors recited about how sensitive physiological stimulation was best for achievement in their experiment. Another set of contributors was awarded typical material about the advantages of disregarding tension throughout a test. In comparison to control participants, pupils under appraisal condition improved across assessments and stated reduced MA at the time of examination. Another path for intervention is to assist students in reducing or regulating their anxieties, which are typically the source of their unfavorable evaluations. To enhance MP, Park et al. (2014) used an animated writing strategy to reduce the frequency of invasive feelings in math-anxious persons. They proposed that people with lower and higher math-anxious that take math aptitude tests before and after an animated writing activity in which they wrote freely about how they perceived an impending mathematics test. After only one session of expressive writing, the higher-math-anxious participants reported a boost in MP compared to their pretest scores, narrowing the performance gap between them and their lower-math-anxious peers. These findings might be explained by the fact that pupils who tackled their bad views and fears obtained perceptions that students who suppressed or ignored their issues did not. This conclusion is in line with what some of the most effective therapies for clinical anxiety disorders have discovered. Past research showed that systematic desensitization and cognitive restructuring are two of the greatest effective therapies for MA (Hembree, 1990).

4.2 Discussion

The current in-depth and state of the art review sought to investigate the relationship between MA and MP in school-going children, as well as to discover possible moderators as well as the underlying processes of such a connection, such as a grade level, temporal relationships, mathematical task difficulty, MA measure dimensions, and perceived importance. Overall, we discovered a moderately unfavorable relationship between MA and mathematics achievement. This is consistent with prior research that found a link between MA and secondary school arithmetic ability. In other words, MA with both affective and cognitive aspects had a higher adverse connection with MP than MA with either unspecified dimension or affective component. When compared to fundamental mathematics domains, advanced mathematics domains that involve multistep measures exhibited a greater adverse link to MA. Mathematics procedures that affected pupil achievements had a greater adverse connection with MA than other procedures that did not affect student grades. Our systematic and state of the art review was guided by three primary theories on the connection between MA and MP: (a) The deficit theory, according to which poor arithmetic proficiency takes to MA; (b) Cognitive interference theory, in which MA impairs MP throughout information pre-processing, processing, and retrieval and (c) The reciprocal theory proposes that MA and MP have a bidirectional relationship, with each influencing the other in a vicious loop. The next sections go through our findings and their implications for each theory:

1. Deficit Theory

One part of the deficit theory is that elementary pupils with an insufficient experience of mathematics have a low to minimum MA. This deficiency of diversity in MA would result in a reduced or non-existent relationship between MA and mathematical achievement in early childhood, but repeated adverse experiences in later school would

result in a greater relationship between MA and MP. In contrast to this notion, our systematic research found that after adjusting for other characteristics, primary and secondary pupils had a comparable degree of relationship between MA and MP. This research implies that MA and MP go hand in hand starting in early infancy. Our findings suggested that MA screening and treatment should begin considerably earlier, in lower elementary schools, so that kids with MA may be recognized early and get early intervention before suffering the negative impacts of MA. However, while grade level represented one feature connected to the deficit theory, it did not give a direct test of the fundamental relationship indicated by the deficit theory. Although there was a little study to integrate the data on either end, studies on students with mathematics learning issues and longitudinal studies would provide more direct evidence on the deficit theory.

2. Cognitive Interference Theory

The cognitive interference theory claims that MA causes poor MP. One of the fundamental mechanisms of this direct relationship is that MA uses working memory, causing pupils to lack sufficient WM for mathematical activities, resulting in low math performance. According to the results of this study, the mechanism by which MA degrades working memory is more complex than simply asserting that MA depletes the WM system's resources.

The literature review in the current study indicated that cognition, such as WM and intelligence, should be taken into account in educational research and practice. The impact of cognition on academic accomplishment, on the other hand, may vary depending on other factors taken into account at the same time. The current review study on the importance of cognition vs domain-specific skills in academic success revealed that domain-specific skills are more proximal determinants for academic accomplishment than cognition as discussed by (Samuel & Warner, 2021). The results of the current study also indicated that when cognition was combined with social characteristics for academic achievements, cognition was determined to be more relevant than domain-specific social or emotional components (Sackett et al., 2009). To investigate the relative relevance of cognition for academic achievement, future research may require examining other relevant cognitive variables, essential domain-specific abilities, and social or emotional components. The cognitive interference theory might also explain why the relationship between MA and MP was greater when MP measurements were used to determine student grades. The findings of current study imply that significant emphasis should be paid to the cognitive mechanism behind MA and math achievement. Our conclusions have significant applications for intervention as concluded by (Casad et al., 2015). Because improper attention to the cognitive components of MA, such as intrusive thought, concern, and preoccupation with performance appraisal, maybe the key to the underlying process, such interventions should include cognitive components as potential intervention targets.

3. Bidirectional Theory

According to the bidirectional theory, MA and arithmetic performance have a reciprocal impact. So, our findings showed that the adverse relationship between MA and MP may be developmental and long-lasting, with each negatively impacting the other in a vicious cycle. Although we can't say whether MA causes bad MP first or conversely, the bidirectional evidence and the small difference in this relationship between elementary and secondary grades propose that forthcoming research on the fundamental relationships between MA and MP should attention to early childhood education at the start of their formal mathematics study. The bidirectional evidence has a significant impact on intervention goals. That is, rather than concentrating on one without the other, intervention efforts for kids with MA should be focused on both lowering MA and remediating mathematical skills impairments. This collaborative approach might be crucial to increasing MA and MP. To that aim, effective ways to minimize MA should be included in mathematics education and treatments. The bidirectional evidence has a significant impact on intervention goals. That is, rather than concentrating on one without the other, intervention efforts for kids with MA should be focused on both lowering MA and remediating mathematical skills impairments. This collaborative approach might be the key to increasing MA and MP. For that purpose, effective measures for reducing MA should be included in mathematics education and interventions, which are currently absent in the research.

4.3 Limitations

The findings of this study should be taken with caution due to several limitations. First, when looking at the link between MP and MA, cross-lagged correlations are skewed in various ways, making it difficult to draw reliable conclusions about the underlying causal linkages between the two. Second, as previously stated, we were unable to examine the deficit theory directly, but we were able to analyze one related element by applying grade level as a substitution. Third, because of the small number of studies, several of our analyses, such as the cognitive vs effective features of MA, may be underpowered.

5. Conclusion

In both primary and secondary schools, MA and MP are inversely connected. The results of this study partially supported the deficit theory as the level of grade did not modify the relationship between MP and MA, while previous math performance predict future MA. The link between MA and MP was larger for more difficult assignments and tasks that affected the pupil's grades and these results supported the cognitive interference argument theory and validated the bidirectional theory. Future experimental investigations is required to confirm the causal relationship between MA and mathematics performance.

References

Baten, E., Pixner, S., & Desoete, A. (2019). Motivational and math anxiety perspective for mathematical learning and learning difficulties. *International Handbook of Mathematical Learning Difficulties: From the Laboratory to the Classroom*, 457-467.

Berkowitz, T., Schaeffer, M. W., Maloney, E. A., Peterson, L., Gregor, C., Levine, S. C., & Beilock, S. L. (2015). Math at home adds up to achievement in school. *Science*, *350*(6257), 196-198.

Bjälkebring, P. (2019, April). Math anxiety at the university: what forms of teaching and learning statistics in higher education can help students with math anxiety? In *Frontiers in Education* (Vol. 4, p. 30). Frontiers Media SA.

Cargnelutti, E., Tomasetto, C., & Passolunghi, M. C. (2017). The interplay between affective and cognitive factors in shaping early proficiency in mathematics. *Trends in neuroscience and education*, *8*, 28-36.

Casad, B. J., Hale, P., & Wachs, F. L. (2015). Parent-child math anxiety and math-gender stereotypes predict adolescents' math education outcomes. *Frontiers in psychology*, *6*, 1597.

Casanova, S., Vukovic, R. K., & Kieffer, M. J. (2021). Do girls pay an unequal price? Black and Latina girls' math attitudes, math anxiety, and mathematics achievement. *Journal of Applied Developmental Psychology*, *73*, 101256.

Chen, Y. C. (2019). Effect of mobile augmented reality on learning performance, motivation, and math anxiety in a math course. *Journal of Educational Computing Research*, *57*(7), 1695-1722.

Ching, B. H. H. (2017). Mathematics anxiety and working memory: Longitudinal associations with mathematical performance in Chinese children. *Contemporary Educational Psychology*, *51*, 99-113.

Foley, A. E., Herts, J. B., Borgonovi, F., Guerriero, S., Levine, S. C., & Beilock, S. L. (2017). The math anxiety-performance link: A global phenomenon. *Current directions in psychological science*, *26*(1), 52-58.

Hart, S. A., & Ganley, C. M. (2019). The nature of math anxiety in adults: Prevalence and correlates. *Journal of numerical cognition*, *5*(2), 122.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for research in mathematics education*, *21*(1), 33-46.

Jamieson, J. P., Peters, B. J., Greenwood, E. J., & Altose, A. J. (2016). Reappraising stress arousal improves performance and reduces evaluation anxiety in classroom exam situations. *Social Psychological and Personality Science*, *7*(6), 579-587.

Klados, M. A., Paraskevopoulos, E., Pandria, N., & Bamidis, P. D. (2019). The impact of math anxiety on working memory: A cortical activations and cortical functional connectivity EEG study. *IEEE Access*, *7*, 15027-15039.

Kucian, K., McCaskey, U., O'Gorman Tuura, R., & von Aster, M. (2018). Neurostructural correlate of math anxiety in the brain of children. *Translational psychiatry*, *8*(1), 273.

Levy, H. E., Fares, L., & Rubinsten, O. (2021). Math anxiety affects females' vocational interests. *Journal of*

Experimental Child Psychology, *210*, 105214.
Liu, J., Li, J., Peng, W., Feng, M., & Luo, Y. (2019). EEG correlates of math anxiety during arithmetic problem solving: Implication for attention deficits. *Neuroscience letters*, *703*, 191-197.
Luo, W., Hogan, D., Tan, L. S., Kaur, B., Ng, P. T., & Chan, M. (2014). Self-construal and students' math self-concept, anxiety and achievement: An examination of achievement goals as mediators. *Asian Journal of Social Psychology*, *17*(3), 184-195.
Ma, X., & Xu, J. (2004). The causal ordering of mathematics anxiety and mathematics achievement: a longitudinal panel analysis. *Journal of adolescence*, *27*(2), 165-179.
Maloney, E. A. (2016). Math anxiety: Causes, consequences, and remediation. In *Handbook of motivation at school* (pp. 408-423). Routledge.
Maloney, E. A., & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in cognitive sciences*, *16*(8), 404-406.
Namkung, J. M., Peng, P., & Lin, X. (2019). The relation between mathematics anxiety and mathematics performance among school-aged students: A meta-analysis. *Review of Educational Research*, *89*(3), 459-496.
Orbach, L., Herzog, M., & Fritz, A. (2019). Relation of state-and trait-math anxiety to intelligence, math achievement and learning motivation. *Journal of Numerical Cognition*, *5*(3), 371-399.
Park, D., Ramirez, G., & Beilock, S. L. (2014). The role of expressive writing in math anxiety. *Journal of Experimental Psychology: Applied*, *20*(2), 103.
Passolunghi, M. C., Caviola, S., De Agostini, R., Perin, C., & Mammarella, I. C. (2016). Mathematics anxiety, working memory, and mathematics performance in secondary-school children. *Frontiers in psychology*, *7*, 42.
Passolunghi, M. C., De Vita, C., & Pellizzoni, S. (2020). Math anxiety and math achievement: The effects of emotional and math strategy training. *Developmental science*, *23*(6), e12964.
Passolunghi, M. C., De Vita, C., & Pellizzoni, S. (2020). Math anxiety and math achievement: The effects of emotional and math strategy training. *Developmental science*, *23*(6), e12964.
Pizzie, R. G., & Kraemer, D. J. (2021). The association between emotion regulation, physiological arousal, and performance in math anxiety. *Frontiers in psychology*, *12*, 639448.
Pizzie, R. G., Raman, N., & Kraemer, D. J. (2020). Math anxiety and executive function: Neural influences of task switching on arithmetic processing. *Cognitive, Affective, & Behavioral Neuroscience*, *20*, 309-325.
Pletzer, B., Kronbichler, M., Nuerk, H. C., & Kerschbaum, H. H. (2015). Mathematics anxiety reduces default mode network deactivation in response to numerical tasks. *Frontiers in human neuroscience*, *9*, 202.
Sackett, P. R., Kuncel, N. R., Arneson, J. J., Cooper, S. R., & Waters, S. D. (2009). Does socioeconomic status explain the relationship between admissions tests and post-secondary academic performance? *Psychological bulletin*, *135*(1), 1.
Samuel, T. S., & Warner, J. (2021). "I can math!": Reducing math anxiety and increasing math self-efficacy using a mindfulness and growth mindset-based intervention in first-year students. *Community College Journal of Research and Practice*, *45*(3), 205-222.
Silver, A. M., Elliott, L., & Libertus, M. E. (2021). When beliefs matter most: Examining children's math achievement in the context of parental math anxiety. *Journal of Experimental Child Psychology*, *201*, 104992.
Supekar, K., Iuculano, T., Chen, L., & Menon, V. (2015). Remediation of childhood math anxiety and associated neural circuits through cognitive tutoring. *Journal of Neuroscience*, *35*(36), 12574-12583.
Thompson, R. J., Napoli, A. R., & Purpura, D. J. (2017). Age-related differences in the relation between the home numeracy environment and numeracy skills. *Infant and Child Development*, *26*(5), e2019.
Vukovic, R. K., Kieffer, M. J., Bailey, S. P., & Harari, R. R. (2013). Mathematics anxiety in young children: Concurrent and longitudinal associations with mathematical performance. *Contemporary educational psychology*, *38*(1), 1-10.
Wang, L. (2020). Mediation relationships among gender, spatial ability, math anxiety, and math achievement. *Educational Psychology Review*, *32*(1), 1-15.

Wu, S. S., Chen, L., Battista, C., Watts, A. K. S., Willcutt, E. G., & Menon, V. (2017). Distinct influences of affective and cognitive factors on children's non-verbal and verbal mathematical abilities. *Cognition*, *166*, 118-129.

Young, W. C., Budynas, R. G., & Sadegh, A. M. (2012). *Roark's formulas for stress and strain*. McGraw-Hill Education.

Zhang, J., Zhao, N., & Kong, Q. P. (2019). The relationship between math anxiety and math performance: A meta-analytic investigation. *Frontiers in psychology*, *10*, 1613.