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Modeling Symptoms of Dyslexia Based on Working Memory and Anxiety with the Mediating Role of Information Processing Speed in Children

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ABSTRACT

Purpose: The present study aimed to predict symptoms of dyslexia based on working memory and anxiety, with the mediating role of information processing speed in children.

Materials and Methods: The research method was correlational with a path analysis design. The statistical population included all male and female students in the fourth to sixth grades during the 2023–2024 academic year in Tehran, from which 300 students were selected using purposive sampling. The research instruments included the Reading and Dyslexia Test (NEMA; Karami Noori & Moradi, 2005), the Dyslexia Checklist (RLDT; Azizzian & Abedi, 2003), the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV), and the Short Form of the Spence Children's Anxiety Scale (SCAS; Ahlen et al., 2018).

Findings: The results of path analysis indicated that the direct effect of working memory on dyslexia symptoms was significant ($p < .05$). The direct effect of anxiety on dyslexia symptoms was also significant ($p < .05$). Furthermore, the direct effect of information processing speed on dyslexia symptoms was significant ($p < .05$). The direct effect of working memory on information processing speed was significant ($p < .05$), and the direct effect of anxiety on information processing speed was also significant ($p < .05$). Additionally, the indirect effect of working memory on dyslexia symptoms through the mediating role of information processing speed was significant ($p < .05$), and the indirect effect of anxiety on dyslexia symptoms through the mediating role of information processing speed was also significant ($p < .05$).

Conclusion: Based on the obtained results, implementing interventions aimed at improving working memory and reducing anxiety may help decrease symptoms of dyslexia in children.

Keywords: *Dyslexia, Anxiety, Working Memory, Information Processing Speed*

1. Introduction

Dyslexia is one of the most prevalent and educationally consequential neurodevelopmental learning disorders in childhood, characterized by persistent difficulties in accurate and/or fluent word recognition, poor decoding, and weaknesses in spelling despite adequate educational opportunity and conventional instruction (American Psychiatric, 2013; Catts et al., 2024; Wolf et al., 2024). Contemporary scholarship has moved beyond narrow, single-deficit explanations and increasingly conceptualizes dyslexia as a multifactorial developmental condition shaped by the interaction of linguistic, cognitive, affective, and contextual processes (Catts et al., 2024; Pennington et al., 2019; Wolf et al., 2024). This shift has important implications for both identification and intervention, because it suggests that reading failure cannot be fully understood by focusing only on phonological deficits or academic outcomes. Rather, comprehensive models should examine domain-general cognitive processes and emotional mechanisms that may intensify, maintain, or partly explain dyslexic symptoms across development (Daniel et al., 2025; Rusciollelli & Sobotka, 2025). In school settings, children with dyslexia often experience not only marked difficulties in decoding and reading fluency but also secondary academic, social, and emotional burdens that may influence motivation, self-concept, and adjustment (Chieffo et al., 2023; Polychroni et al., 2024). Therefore, investigating the cognitive and emotional architecture underlying dyslexia is not merely a theoretical task; it is essential for improving assessment, prevention, and intervention frameworks.

Recent debates concerning the definition and identification of dyslexia further underscore the need for integrative explanatory models. Researchers have emphasized that dyslexia should be recognized through dynamic, multidimensional assessment systems that capture reading symptoms alongside underlying risk factors and associated cognitive processes (Catts et al., 2024; Daniel et al., 2025; Rusciollelli & Sobotka, 2025). A growing body of work has criticized overly static or exclusively achievement-based screening approaches, arguing that children may present with heterogeneous profiles of impairment and that a broader model can better explain individual variation in severity and manifestation (Daniel et al., 2025; Wolf et al., 2024). In the same line, applied perspectives in educational and pediatric settings have highlighted the importance of early screening for specific learning disorders and of identifying the mechanisms that connect cognitive

performance to functional reading outcomes (Rusciollelli & Sobotka, 2025). Within this framework, symptoms of dyslexia are increasingly viewed as the outcome of overlapping deficits across phonological processing, working memory, processing speed, attentional control, and emotional functioning rather than as the direct product of a single isolated cause (Moll et al., 2016; Pennington et al., 2019). This multidimensional understanding creates a strong rationale for examining working memory and anxiety simultaneously, while also considering information processing speed as a possible explanatory pathway.

Among the cognitive variables associated with dyslexia, working memory has received sustained empirical and theoretical attention. Working memory refers to the limited-capacity system responsible for the temporary storage and active manipulation of information necessary for complex cognitive tasks such as comprehension, learning, and goal-directed performance (Pickering, 2012; Wout et al., 2019). Reading, especially fluent and accurate reading, places substantial demands on working memory because the child must retain phonological information, integrate orthographic patterns, coordinate visual and verbal input, inhibit distractions, and link current input with lexical knowledge and sentence context (Pickering, 2012; Smith-Spark & Fisk, 2007). Deficits in working memory may therefore disrupt several stages of the reading process, from grapheme-phoneme conversion to word identification, fluency, and comprehension. Evidence from children with dyslexia has repeatedly shown poorer performance on verbal and complex working memory tasks compared with typically developing peers, suggesting that working memory is not merely correlated with reading difficulties but may represent one of the core vulnerability factors within dyslexic profiles (Gray et al., 2019; Smith-Spark & Fisk, 2007; Toffalini et al., 2019). Furthermore, comparative studies have demonstrated that children with dyslexia may exhibit distinct working memory profiles relative to those with developmental language disorder or combined conditions, indicating that working memory impairment may contribute meaningfully to the heterogeneity of learning problems (Gray et al., 2019).

The relation between working memory and dyslexia also appears to operate through specific intermediate mechanisms. Research has shown that phonological awareness may mediate the association between working memory and word reading efficiency in children with dyslexia, indicating that working memory supports core phonological and decoding operations rather than simply co-

occurring with them (Knoop-van Campen et al., 2018). Serial order memory has likewise been linked to reading ability in children with and without dyslexia, suggesting that the ability to temporarily maintain and sequence verbal units contributes to accurate reading performance (Hachmann et al., 2020). In addition, cross-modal binding deficits in working memory have been reported in reading disability, further illustrating that the problem may extend beyond simple storage limitations to the integration of multimodal information (Toffalini et al., 2019). Studies on cognitive risk factors for specific learning disorder have consistently identified working memory as one of the major domain-general contributors to reading difficulties (Moll et al., 2016). Intervention findings reinforce this view: training working memory has been associated with gains in reading-related outcomes in some samples of students with reading disability, although the magnitude and stability of these effects remain open to discussion (Maehler et al., 2019; Sheikholeslami et al., 2017). Collectively, these findings justify the inclusion of working memory as a primary explanatory variable in models of dyslexia symptoms.

Another construct that deserves greater attention in dyslexia research is anxiety. Although dyslexia is fundamentally classified as a learning disorder rather than an emotional disorder, children with dyslexia frequently experience elevated anxiety due to repeated academic failure, fear of negative evaluation, performance pressure, and chronic classroom frustration (Chieffo et al., 2023; Polychroni et al., 2024). Importantly, the relationship between anxiety and dyslexia is likely bidirectional. On the one hand, ongoing reading difficulties may generate distress and reduce confidence; on the other hand, heightened anxiety may disrupt attentional control, reduce cognitive efficiency, and worsen academic performance, thereby intensifying dyslexic symptoms. Recent evidence indicates that primary school children with dyslexia show meaningful associations among reading self-concept, trait emotional intelligence, and anxiety, highlighting the emotional vulnerability of this population (Polychroni et al., 2024). Behavior-related impairments and comorbid symptoms have also been documented among children with specific learning disorders, suggesting that emotional and behavioral correlates are not peripheral but clinically relevant components of the broader presentation (Chieffo et al., 2023). From this perspective, anxiety should not be treated merely as an outcome of dyslexia but also as a variable that may directly and indirectly shape reading-related functioning.

The cognitive consequences of anxiety provide a strong basis for integrating it into explanatory models of dyslexia. According to attentional control perspectives, anxiety consumes processing resources, biases attention toward threat or worry, and reduces task efficiency, particularly in situations that require rapid, controlled, and sustained cognitive performance. Empirical studies have shown that anxiety is negatively associated with processing speed in children, including children with dyslexia, and that this relation can influence reading comprehension and performance (Wang et al., 2022; Wang et al., 2024). In one study of Chinese children with and without reading disabilities, processing speed played an important role in the link between anxiety and reading comprehension, suggesting that anxiety-related slowing may be one mechanism through which emotional distress undermines academic functioning (Wang et al., 2022). More recent work has further demonstrated that anxiety and processing speed are closely connected in children with and without dyslexia when viewed through the lens of attentional control theory (Wang et al., 2024). These findings imply that anxiety may exert its impact on dyslexic symptoms partly by reducing the speed and efficiency with which information is encoded, scanned, and integrated during reading tasks. Such a mediational pathway is especially plausible in school-aged children whose reading tasks require both rapid processing and emotional regulation under evaluative conditions.

Information processing speed itself has been widely identified as a critical domain-general factor in learning and reading. Processing speed refers to the efficiency with which an individual can perceive, interpret, and respond to information under time constraints. In reading, processing speed affects rapid naming, visual scanning, orthographic decoding, fluency, and the coordination of multiple low-level and high-level operations during text processing (Moll et al., 2016; Tejero et al., 2019). The importance of processing speed is not confined to reading disorders; broader neuropsychological evidence indicates that processing speed is closely tied to neural efficiency and working memory performance, with slower processing limiting the cognitive resources available for complex tasks (Covey et al., 2011). Similarly, work on children with attention-related difficulties has shown that working memory influences processing speed and reading fluency, supporting the view that these cognitive dimensions are functionally interconnected rather than independent constructs (Jacobson et al., 2011). Within dyslexia research, slower processing speed has repeatedly emerged as one of

the major cognitive risk factors associated with poor reading outcomes (Moll et al., 2016). Therefore, processing speed may operate as a mechanism linking both working memory limitations and anxiety-related inefficiency to observable dyslexic symptoms.

From a developmental and functional standpoint, the mediating role of processing speed is theoretically compelling. Children with stronger working memory can maintain and manipulate task-relevant information more efficiently, which may facilitate faster lexical access, smoother decoding, and more fluent reading. Conversely, reduced working memory capacity can overload the system, delay response selection, and slow information handling across reading-related tasks (Jacobson et al., 2011; Pickering, 2012). This logic is consistent with studies indicating close links among working memory, speed, and academic performance, as well as with findings that domain-general cognitive deficits can propagate through intermediate mechanisms before manifesting as reading symptoms (Covey et al., 2011; Moll et al., 2016). At the same time, anxiety may interfere with processing speed by dividing attention, increasing cognitive load, and promoting inefficiency in performance monitoring (Wang et al., 2024). When both working memory weakness and anxiety are present, their combined effect may be especially detrimental to children already struggling with reading acquisition. Thus, a model in which information processing speed mediates the effects of working memory and anxiety on dyslexia symptoms is aligned with both cognitive theory and emerging empirical evidence.

A further reason to examine this model is that dyslexia presents with broad functional consequences extending beyond laboratory reading tasks. Difficulties in reading can affect daily activities, classroom participation, and even tasks such as interpreting visual-verbal symbols in natural environments. For example, research has shown that individuals with dyslexia may experience difficulties reading traffic signs, with observable differences in reading behavior, eye movements, and performance under realistic conditions (Tejero et al., 2019). Prosodic skills, both linguistic and non-linguistic, have also been shown to differ in children with developmental dyslexia, indicating that the disorder can involve broader timing and processing-related challenges than is often assumed (Calet et al., 2019). These findings reinforce the need to move beyond simplistic symptom descriptions toward models that account for multiple interacting cognitive processes. Such models are especially relevant for educational planning because they

can identify targets for intervention that are more specific than the global label of reading disability.

The present study is also justified by practical needs in assessment and screening. Accurate identification of dyslexia requires valid tools that capture symptoms as well as relevant correlates. In Iranian contexts, the NEMA Reading and Dyslexia Test and the Reading Level Diagnostic Test have provided localized tools for identifying reading difficulties and dyslexia-related symptoms in children (Azizian & Abedi, 2003; Karami Noori & Moradi, 2005). Subsequent Iranian studies have supported the utility of these measures in intervention and diagnostic work and have emphasized the importance of using standardized, contextually appropriate instruments (Amrollahi Biouki & Hosseinkhazadeh, 2017; Heydari et al., 2012; Sheikholeslami et al., 2017). Likewise, the assessment of child anxiety requires psychometrically sound tools. The short form of the Spence Children's Anxiety Scale has demonstrated acceptable psychometric properties internationally, and its enhanced short form has been validated in Iran, providing a reliable basis for evaluating anxiety in school-aged samples (Ahlen et al., 2018; Amiralsadat Hafshejani et al., 2021). The availability of these instruments makes it possible to test theoretically grounded structural relationships among dyslexia symptoms, working memory, anxiety, and processing speed within local populations rather than relying solely on imported findings.

Methodologically, the use of structural modeling approaches such as path analysis or PLS-based modeling offers an advantage in testing complex relations among observed constructs. Such approaches allow simultaneous estimation of direct and indirect paths and are particularly useful when the research question concerns mediation and interdependence among predictors (Hair et al., 2019). Given the multidimensional nature of dyslexia and the probable interplay among cognitive and emotional variables, an analytic framework that goes beyond bivariate associations is essential. This is consistent with contemporary scholarship that encourages moving from simple deficit-description models toward integrated explanatory systems capable of representing layered mechanisms in developmental disorders (Pennington et al., 2019; Wolf et al., 2024). Although several studies have separately examined working memory, anxiety, or processing speed in relation to reading difficulties, fewer have tested a unified model in which working memory and anxiety predict dyslexia symptoms both directly and indirectly through

information processing speed, especially among upper elementary school children in non-Western educational contexts. This gap is theoretically important because the coexistence of cognitive weakness and emotional distress may explain why some children exhibit more severe or persistent reading symptoms than others despite comparable instructional exposure.

In summary, dyslexia is now understood as a dynamic and multifactorial disorder involving the interaction of reading-specific and domain-general processes (Catts et al., 2024; Wolf et al., 2024). Working memory has emerged as a robust cognitive correlate of reading difficulties, anxiety has been increasingly recognized as a relevant emotional factor in children with dyslexia, and information processing speed appears to be a plausible mechanism through which both may affect reading-related outcomes (Gray et al., 2019; Smith-Spark & Fisk, 2007; Wang et al., 2022; Wang et al., 2024). At the same time, advances in screening, assessment, and conceptualization of specific learning disorders have created the opportunity to investigate these relations in a more integrated manner (Daniel et al., 2025; Rusciollelli & Sobotka, 2025). The aim of the present study was to model symptoms of dyslexia based on working memory and anxiety with the mediating role of information processing speed in children.

2. Methods and Materials

2.1. Study Design and Participants

The present study was applied in terms of purpose and correlational in nature and method, using a path analysis design in which the relationships among the exogenous variables (working memory and anxiety), the mediating variable (processing speed), and the endogenous variable (dyslexia) were examined. The statistical population of this study included all male and female students in the fourth to sixth grades who had been referred to educational and rehabilitation centers for specific learning problems in Tehran during the 2023–2024 academic year due to reading difficulties. Fourth to sixth grades were selected because students at these grade levels possessed the necessary comprehension to respond to the research questions. From this population, 300 students (150 girls and 150 boys) were selected using purposive sampling. Although there is no universal consensus regarding the required sample size for structural models, many researchers recommend a minimum sample size of 300 participants. Therefore, a sample of 300 was considered for the present study.

The inclusion criteria for participation were as follows: willingness and readiness of the students to participate in the study, signed written parental consent, enrollment in the fourth through sixth grades of elementary school, poor reading performance based on the relevant teacher's report, average intellectual functioning (a score of 85 or above on the Wechsler Intelligence Scale for Children–Fourth Edition), a score two standard deviations below the mean on the NEMA Reading and Dyslexia Test, absence of other disorders such as significant physical-motor disability, no use of psychiatric medications, and absence of specific visual, hearing, speech, or language problems. Participants were excluded from the study if any of the following conditions were identified: the presence of other emotional-behavioral disorders such as attention-deficit/hyperactivity disorder, unwillingness to continue participation in the study, or cultural and bilingualism-related problems, including difficulties arising from accent and weakness in lexical and grammatical use of the Persian language.

The study was conducted in three stages. In the first stage, ethical approval was obtained from the Ethics Committee for Research at the Islamic Azad University, Shahrekord Branch, under code IR.IAU.SHK.REC.1402.151. In the second stage, a research permission letter was obtained from the Islamic Azad University, Shahrekord Branch, for submission to the Tehran Exceptional Education Department. In the third stage, after the necessary coordination with specialists at the Educational and Rehabilitation Center for Specific Learning Problems in Tehran, 300 referred students, including 150 girls and 150 boys, who had been placed on the waiting list during the 2023–2024 academic year for diagnosis and treatment of specific learning disorder with impairment in reading, were selected from the study population through purposive sampling, provided that both they and their parents had expressed willingness to participate. The inclusion and exclusion criteria were then evaluated for all selected participants as described above. Since 300 cases are considered desirable for path and structural analysis models, this number was adopted in the present study. Subsequently, senior specialists and experts at the Educational and Rehabilitation Center for Specific Learning Problems assessed all selected participants for the presence of specific learning disorder with impairment in reading based on the diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5), using clinical interviews, the Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV), and the NEMA Reading and

Dyslexia Diagnostic Test. Thereafter, the remaining research instruments were administered to the participants in one or two sessions, depending on the child's level of ability and readiness. For data analysis, both descriptive and inferential statistics were used. In the descriptive section, frequency, percentage, mean, and standard deviation were calculated. Before testing the study hypotheses, the assumption of normality was examined using skewness and kurtosis, and the data were then analyzed using path analysis. Ethical considerations included obtaining ethics approval from the university ethics committee, securing parental consent for questionnaire distribution and administration of the relevant procedures, observing scientific honesty and integrity, obtaining informed consent for participation, ensuring anonymity of the scales and confidentiality of participants' identities, and maintaining the confidentiality of their information.

2.2. Measures

NEMA Reading and Dyslexia Test (NEMA): This test was developed and standardized by Karami Noori and Moradi in 2005 for monolingual (Persian-speaking) and bilingual (Tabrizi and Sanandaji) male and female students in the first to fifth grades of elementary school. The purpose of this test is to assess the reading ability of typically developing male and female elementary school students and to identify children with reading problems and dyslexia. It is administered individually. The test consists of 10 subtests: high- and low-frequency word reading, word chain, rhyme, picture naming, text comprehension, word comprehension, phoneme deletion, nonword and pseudoword reading, letter signs, and signs. Based on the cutoff score of this test (157), a student who obtains a score of 157 or lower (114 errors or more) is diagnosed as having dyslexia (Karami Noori & Moradi, 2005). The test was standardized on 1,614 students across five elementary grade levels in the three cities of Tehran, Sanandaj, and Tabriz, and the total alpha coefficient of the test in that study was reported as 0.82. After data collection and statistical analysis, raw scores and normative scores were calculated for each grade in each city. In addition, in another study, the reliability of this test, assessed using Cronbach's alpha coefficient, was reported as 0.71 (Heydari et al., 2012).

Reading Learning Disability Test Checklist (RLDT): In the present study, the Reading Learning Disability Test Checklist developed by Azizzian and Abedi was used to identify students with dyslexia. This checklist contains 15

dichotomous yes/no items completed by the teacher, with a total score ranging from 0 to 15. The instrument was standardized among students in Isfahan and includes four levels: preschool, elementary, middle school, and high school. The validity of the test was established through the correlation coefficient between the total test score and IQ, which was 0.63, and its test-retest reliability was reported as 0.93 (Azizzian & Abedi, 2003). The reliability coefficient for the total score has also been reported to range from 0.41 to 0.95 (Amrollahi Biouki & Hosseinkhazadeh, 2017). This checklist is used in most learning disability clinics affiliated with the Exceptional Education Organization as a valid instrument for identifying students suspected of having reading disability. It has also been shown that individuals who displayed no reading-related problems in 94% of cases on the dyslexia symptom checklist were identified as having normal word reading ability (Sheikholeslami et al., 2017).

Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV): The study instruments included six subtests from the WISC-IV: Coding, Symbol Search, and Cancellation, which assess the Processing Speed Index, and Digit Span, Arithmetic, and Letter-Number Sequencing, which assess the Working Memory Index. The three subtests of Coding, Symbol Search, and Cancellation collectively constitute the processing speed factor in the WISC-IV. A high score on these subtests indicates that the individual can take in information rapidly and integrate it efficiently. The Digit Span, Arithmetic, and Letter-Number Sequencing subtests are also drawn from this test battery. These verbal short-term memory subtests require attention, accurate encoding, and precise retrieval of information. Wechsler reported an internal consistency reliability coefficient of 0.85 for the Coding subtest using the Guilford formula (1945). In his studies, he reported the reliability coefficient for the Symbol Search subtest as 0.79. The test-retest reliability coefficient for the Digit Span subscale was reported as 0.83. In addition, the reliability coefficient for the Visual Memory subscale was reported as 0.82. In Iran, the reliability of this test was also assessed by Saeed et al. using the split-half method, with a Cronbach's alpha of 0.78.

Short Form of the Spence Children's Anxiety Scale (SCAS-S): This scale was developed by Ahlen et al. in 2018 with the aim of creating a shortened version of the Spence Children's Anxiety Scale while preserving the content, convergent, and discriminant validity of the original measure (Ahlen et al., 2018). A school sample of 750 participants was used to reduce the number of items, and an independent school sample of 371 participants, along with a clinical

sample of 93 participants, was used to validate the short form. The resulting short version of the Spence Children’s Anxiety Scale contained 19 items measuring five components: social anxiety (items 4, 6, and 7), separation anxiety (items 3, 5, and 19), specific phobia (items 2, 13, 15, and 18), panic-agoraphobia (items 9, 11, 14, 16, and 17), and generalized anxiety (items 1, 8, 10, and 12). Responses are scored on a four-point Likert scale ranging from never = 0 to sometimes = 1, often = 2, and always = 3. In the study by Ahlen et al. (2018), Cronbach’s alpha coefficients were 0.89 for the total questionnaire, 0.62 for separation anxiety, 0.70 for social anxiety, 0.78 for panic-agoraphobia, 0.65 for specific phobia, and 0.76 for generalized anxiety (Ahlen et al., 2018). In Iran, this questionnaire was standardized by Amir al-Sadat Hefshjani et al. in 2021 among all 8- to 12-year-old elementary school students in Rasht during the 2019–2020 academic year. Construct validity was examined using both exploratory and confirmatory factor analyses. Receiver operating characteristic curve analysis was used to determine the cutoff point. Reliability was assessed in terms of internal consistency using Cronbach’s alpha, stability using the test-retest method with the intraclass correlation coefficient, and homogeneity using inter-item correlations, item-total correlations, and correlations among items. Among the participants, 275 (55%) were girls and 225 (45%) were boys. Factor analysis showed that the scale had five components—panic-agoraphobia, generalized anxiety,

specific phobia, social anxiety, and separation anxiety—with desirable fit indices. Cronbach’s alpha values were 0.939 for the total scale and 0.812, 0.894, 0.803, 0.709, and 0.801 for panic-agoraphobia, generalized anxiety, specific phobia, social anxiety, and separation anxiety, respectively. The most appropriate cutoff point for the scale was calculated as 24.5 (Amiralsadat Hafshejani et al., 2021).

2.3. Data Analysis

For the analysis of descriptive data, SPSS version 25 was used. Because the data for some variables in the present study were not normally distributed, PLS version 3.3 was used for analysis and fitting of the conceptual model, since this software operates based on the partial least squares approach and is not sensitive to non-normal sampling distributions or sample size. All inferential analyses were conducted at a significance level of 0.05.

3. Findings and Results

Of the children studied, 150 (50%) were girls and 150 (50%) were boys. Among the girls, 40 (26.66%) were 10 years old, 58 (38.66%) were 11 years old, and 52 (34.66%) were 12 years old. Among the boys, 50 (33.33%) were 10 years old, 44 (29.33%) were 11 years old, and 56 (37.33%) were 12 years old.

Table 1

Descriptive Indices and Correlation Coefficients of the Study Variables (N = 300)

Variable	1	2	3	4
1. Working memory	1			
2. Processing speed	.64**	1		
3. Anxiety	.32**	-.56**	1	
4. Dyslexia	-.52**	-.59**	.62**	1
Mean	18.31	31.95	39.61	13.11
Standard deviation	6.70	6.32	5.20	2.55
Skewness	.01	.03	.03	.40
Kurtosis	-.24	-.72	-.72	.57

The mean and standard deviation of the study variables in the sample are presented in Table 1. The skewness and kurtosis values shown in Table 1 indicate that all variables had a normal distribution. The variance inflation factor values for working memory, processing speed, and anxiety were 1.00, 1.00, and 0.90, respectively. The condition index values for working memory, processing speed, and anxiety were 14.11, 19.83, and 15.47, respectively, indicating the

absence of multicollinearity among the predictor variables. In addition, the Durbin-Watson statistics for working memory, processing speed, and anxiety were 1.71, 1.98, and 1.83, respectively, indicating the independence of the data. After examining and confirming the assumptions of path analysis, the conceptual model was fitted, and the results are presented in Figure 1 and Tables 2 and 3.

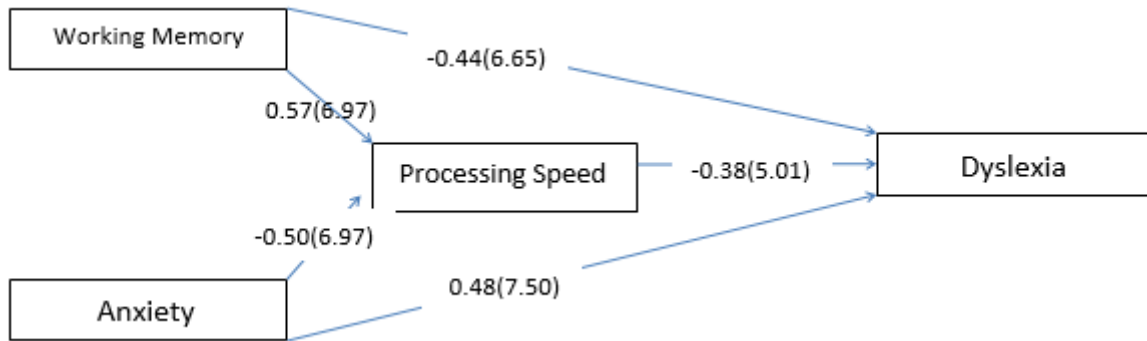
Table 2

Estimates of Direct Effect Coefficients

Path	β	95% CI	T	p
Direct effects				
Working memory → Symptoms of dyslexia	-.44	[-.40, -.21]	6.65	.0001
Anxiety → Symptoms of dyslexia	.48	[.22, .18]	7.50	.0001
Information processing speed → Symptoms of dyslexia	-.38	[-.43, -.26]	5.01	.001
Working memory → Information processing speed	.57	[.49, .37]	6.97	.001
Anxiety → Information processing speed	-.50	[-.30, -.31]	6.97	.001
Indirect effects				
Working memory → Processing speed → Symptoms of dyslexia	-.21	[-.24, -.19]	3.90	.0001
Anxiety → Processing speed → Symptoms of dyslexia	.25	[.27, .10]	5.22	.0001

Figure 1

Fitted model of symptoms of dyslexia based on working memory and anxiety with the mediating role of information processing speed in upper elementary school children in Tehran



As shown in Table 2, the direct effect of working memory on symptoms of dyslexia was significant ($p < .05$). The direct effect of anxiety on symptoms of dyslexia was also significant ($p < .05$). The direct effect of information

processing speed on symptoms of dyslexia was significant ($p < .05$). The direct effect of working memory on information processing speed was also significant ($p < .05$).

Table 3

Estimates of Indirect Effects (Bootstrap)

Path	β	95% CI	T	p
Working memory → Processing speed → Symptoms of dyslexia	-.21	[-.24, -.19]	3.90	.0001
Anxiety → Processing speed → Symptoms of dyslexia	.25	[.27, .10]	5.22	.0001

Based on the results presented in Table 3, the direct effect of anxiety on information processing speed was significant ($p < .05$). The indirect effect of working memory on symptoms of dyslexia through the mediating role of information processing speed was significant ($p < .05$). The indirect effect of anxiety on symptoms of dyslexia through the mediating role of information processing speed was also significant ($p < .05$).

Regarding the goodness of fit of the model, although there is no absolute standard for these indices in the theoretical literature, a standardized root mean square residual equal to or less than .08 and a normed fit index equal to or greater than .90 are considered acceptable (25). In the present study, the obtained value for the standardized root mean square residual was .000, and the normed fit index was 1.00, both of which indicate an adequate model fit. In addition to these indices, the goodness-of-fit index (GOF)

was also used. This index reflects the compatibility between the quality of the structural model and the measurement model. In the present study, the GOF value was calculated as .38. A goodness-of-fit value greater than .36 indicates desirable model fit. Since the GOF value obtained in the present study was .38, which is greater than .36, the model demonstrated an appropriate fit.

4. Discussion and Conclusion

The present study aimed to model symptoms of dyslexia based on working memory and anxiety with the mediating role of information processing speed in children, and the findings provided empirical support for the proposed structural relationships. The results indicated that working memory had a significant negative direct effect on dyslexia symptoms, suggesting that higher levels of working memory are associated with fewer dyslexic symptoms. This finding aligns with a substantial body of literature emphasizing the central role of working memory in reading processes and learning disorders. Working memory is critical for temporarily storing and manipulating phonological and orthographic information during reading tasks, and deficits in this system can disrupt decoding, fluency, and comprehension processes (Pickering, 2012; Smith-Spark & Fisk, 2007). Previous studies have consistently demonstrated that children with dyslexia exhibit weaker working memory performance compared to typically developing peers, which contributes to their reading difficulties (Gray et al., 2019; Toffalini et al., 2019). Moreover, research has shown that working memory deficits are not only associated with dyslexia but also function as a cognitive risk factor that can predict reading performance over time (Moll et al., 2016). The present findings are also consistent with studies indicating that improving working memory capacity may lead to improvements in reading-related skills, highlighting the causal relevance of this construct (Maehler et al., 2019; Sheikholeslami et al., 2017). Therefore, the observed negative association between working memory and dyslexia symptoms reinforces the theoretical view that working memory is a foundational cognitive component underlying reading acquisition and performance.

In addition to the role of working memory, the results showed that anxiety had a significant positive direct effect on dyslexia symptoms, indicating that higher levels of anxiety are associated with more severe dyslexic symptoms. This finding is consistent with research suggesting that

children with dyslexia often experience elevated levels of anxiety due to repeated academic failure, negative feedback, and social comparison in educational settings (Chieffo et al., 2023; Polychroni et al., 2024). Anxiety can impair cognitive performance by consuming attentional resources, increasing cognitive load, and reducing the efficiency of information processing. According to attentional control theory, anxious individuals allocate more cognitive resources to threat-related or worry-related stimuli, which diminishes the resources available for task-relevant processing (Wang et al., 2024). Empirical evidence supports this mechanism, showing that anxiety is negatively associated with reading comprehension and academic performance in children with and without reading disabilities (Wang et al., 2022). The current findings extend this literature by demonstrating that anxiety not only coexists with dyslexia but also directly contributes to the severity of its symptoms. This highlights the importance of considering emotional factors alongside cognitive variables in explaining learning difficulties, as emphasized in multidimensional models of dyslexia (Pennington et al., 2019; Wolf et al., 2024).

Another important finding of the present study was that information processing speed had a significant negative direct effect on dyslexia symptoms. This indicates that faster processing speed is associated with fewer dyslexic symptoms, whereas slower processing is linked to greater reading difficulties. This result is consistent with previous research identifying processing speed as a key cognitive factor in reading development and learning disorders (Moll et al., 2016). Processing speed influences multiple aspects of reading, including rapid naming, visual scanning, and the integration of phonological and orthographic information. When processing speed is reduced, the efficiency of these operations declines, leading to difficulties in fluent and accurate reading. Neuropsychological evidence has also demonstrated that processing speed is closely related to neural efficiency and cognitive performance, further supporting its role in academic functioning (Covey et al., 2011). Studies involving children with reading disabilities have shown that slower processing speed is associated with poorer reading outcomes, reinforcing its importance as a predictor of dyslexia symptoms (Tejero et al., 2019). The present findings thus confirm that processing speed is not merely a peripheral factor but a core component of the cognitive architecture underlying dyslexia.

The study also found that working memory had a significant positive direct effect on information processing speed, indicating that higher working memory capacity is

associated with faster processing speed. This finding is theoretically consistent with models that conceptualize cognitive processing as an integrated system in which working memory supports efficient information handling. Individuals with stronger working memory are better able to maintain task-relevant information, coordinate multiple cognitive processes, and respond more quickly to stimuli, thereby enhancing processing speed (Covey et al., 2011; Jacobson et al., 2011). Empirical studies have shown that working memory influences processing speed and reading fluency, particularly in populations with neurodevelopmental difficulties (Jacobson et al., 2011). Furthermore, research on children with dyslexia has demonstrated that working memory deficits can lead to slower processing and reduced reading efficiency (Moll et al., 2016). The present findings therefore support the idea that working memory contributes indirectly to reading outcomes by facilitating faster and more efficient information processing.

In contrast, anxiety was found to have a significant negative direct effect on information processing speed, indicating that higher anxiety levels are associated with slower processing speed. This finding is consistent with attentional control theory, which posits that anxiety disrupts cognitive efficiency by diverting attention away from task-relevant stimuli and increasing mental effort (Wang et al., 2024). Empirical research has shown that anxiety is associated with reduced processing speed and cognitive performance in children, particularly in tasks requiring sustained attention and rapid information processing (Wang et al., 2022). The present results extend this line of research by demonstrating that anxiety negatively affects processing speed in children with reading difficulties, thereby contributing to dyslexia symptoms. This finding highlights the importance of addressing emotional factors in educational interventions, as anxiety may hinder not only motivation but also the cognitive processes necessary for learning.

One of the most significant contributions of this study is the identification of information processing speed as a mediating variable in the relationship between working memory, anxiety, and dyslexia symptoms. The results showed that working memory had a significant indirect effect on dyslexia symptoms through processing speed, indicating that part of the influence of working memory on reading difficulties operates through its impact on processing efficiency. This finding is consistent with previous research suggesting that phonological awareness

and other intermediate variables mediate the relationship between working memory and reading performance (Knoop-van Campen et al., 2018). By demonstrating a similar mediating role for processing speed, the present study adds to the growing evidence that cognitive variables influence reading outcomes through complex pathways rather than direct effects alone. Similarly, anxiety was found to have a significant indirect effect on dyslexia symptoms through processing speed, suggesting that anxiety exacerbates reading difficulties partly by slowing cognitive processing. This finding aligns with studies showing that anxiety affects academic performance through its impact on cognitive efficiency and attentional control (Wang et al., 2024). Together, these results support a comprehensive model in which both cognitive and emotional factors influence dyslexia symptoms through shared mechanisms, highlighting the importance of considering multiple pathways in understanding learning disorders.

The overall model demonstrated a good fit to the data, as indicated by the goodness-of-fit indices, suggesting that the proposed relationships among variables provide an adequate representation of the underlying processes. This finding is consistent with methodological recommendations emphasizing the use of structural equation modeling approaches to examine complex relationships among variables in educational and psychological research (Hair et al., 2019). The strong model fit supports the validity of the proposed theoretical framework and provides empirical evidence for the integrated role of working memory, anxiety, and processing speed in explaining dyslexia symptoms. Furthermore, the use of standardized and validated instruments, such as the NEMA test and the SCAS, enhances the reliability and generalizability of the findings (Ahlen et al., 2018; Amiralsadat Hafshejani et al., 2021; Karami Noori & Moradi, 2005). These results are also consistent with contemporary perspectives that emphasize the need for multidimensional assessment and intervention approaches in the field of learning disabilities (Daniel et al., 2025; Rusciollelli & Sobotka, 2025).

Another important implication of the findings is their contribution to the ongoing debate regarding the conceptualization of dyslexia. The results support a multidimensional model in which dyslexia is influenced by the interaction of cognitive and emotional factors rather than being solely a phonological deficit. This perspective is consistent with recent theoretical frameworks that emphasize the dynamic and complex nature of dyslexia (Catts et al., 2024; Wolf et al., 2024). By demonstrating the

roles of working memory, anxiety, and processing speed, the present study provides empirical support for this broader conceptualization and highlights the need for integrative approaches in both research and practice. In addition, the findings have practical implications for screening and intervention, as they suggest that assessing cognitive and emotional factors may improve the identification of children at risk for dyslexia and inform more targeted interventions.

The findings also contribute to the literature by focusing on children in upper elementary school, a developmental stage in which reading skills become increasingly important for academic success. At this stage, deficits in reading can have significant consequences for learning across subjects, as well as for self-esteem and motivation. By identifying the cognitive and emotional factors associated with dyslexia symptoms in this population, the study provides valuable insights for educators and clinicians working with children who struggle with reading. Moreover, the use of a structural model allows for a more nuanced understanding of the relationships among variables, which can inform the development of more effective intervention strategies.

One limitation of the present study is that it employed a correlational design, which precludes definitive conclusions about causal relationships among variables. Although path analysis allows for the examination of directional relationships, the results should be interpreted with caution, as alternative models may also explain the observed data. Another limitation is the reliance on a specific sample of students referred to learning disability centers in one urban context, which may limit the generalizability of the findings to other populations. In addition, the use of self-report and teacher-report measures may introduce bias, as responses may be influenced by subjective perceptions or social desirability. Finally, although the study examined key cognitive and emotional variables, other relevant factors, such as phonological awareness, attentional control, and environmental influences, were not included in the model and may also contribute to dyslexia symptoms.

Future research should consider using longitudinal designs to examine the developmental trajectories of working memory, anxiety, and processing speed in relation to dyslexia symptoms. Such studies would provide stronger evidence for causal relationships and help identify critical periods for intervention. Researchers are also encouraged to include additional variables, such as phonological processing, executive functions, and family or educational factors, to develop more comprehensive models of dyslexia. Moreover, future studies could explore the effectiveness of

interventions targeting both cognitive and emotional factors, as well as their combined impact on reading outcomes. Cross-cultural research would also be valuable in examining whether the observed relationships hold across different linguistic and educational contexts.

From a practical perspective, the findings of this study suggest that interventions for children with dyslexia should adopt a multidimensional approach that addresses both cognitive and emotional factors. Programs aimed at improving working memory and processing speed may enhance reading performance, while interventions targeting anxiety may reduce emotional barriers to learning. Educators and clinicians should consider incorporating strategies such as cognitive training, emotional regulation techniques, and supportive learning environments to address the diverse needs of children with dyslexia. Early identification and intervention are particularly important, as they can prevent the development of secondary problems such as low self-esteem and academic disengagement. By addressing both the cognitive and emotional aspects of dyslexia, it may be possible to improve outcomes for affected children and support their academic and personal development.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the study and participated in the research with informed consent. Ethical approval was obtained from the Ethics Committee for Research at the Islamic Azad University, Shahrekord Branch, under code IR.IAU.SHK.REC.1402.151.

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