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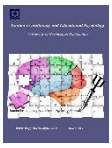

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Comparison of Visual-Spatial Performance, Attention Problems, and Cognitive Processing Speed in Male Students with and without Specific Learning Disabilities in Writing

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Abstract: Specific learning disabilities (SLDs) represent a group of neurodevelopmental disorders characterized by difficulties in acquiring academic skills in one or more areas. These difficulties persist despite typical intelligence and sufficient access to educational resources. In 2021, a research study was conducted in Tabriz, Iran, with the objective of comparing visual-spatial performance, attention problems, and cognitive processing speed among male students with and without specific learning disabilities in writing. This research adopted a casual-comparative method, selecting two groups of 60 third-grade male students through purposive sampling. One group comprised students with diagnosed learning disabilities in writing, who were under the care of the Learning Disabilities Center. The other group consisted of typically developing students attending regular schools. Data collection involved the utilization of the Conners Neuropsychological Scale (2004), and data analysis employed a multivariate analysis of variance (MANOVA). The study's results revealed significant differences in attention-related problems, cognitive processing speed, and visual-spatial performance between students with learning disabilities in writing and their typically developing peers. These findings offer valuable insights for educators working with students facing learning disabilities and for psychologists involved in their care.

Keywords: Attention problems, cognitive processing speed, visual-spatial performance, learning disabilities, writing disorder

Introduction

Special learning disorders refer to a group of developmental neurological disorders characterized by abnormalities in cognitive functions related to behavioral symptoms, comprehension, efficient processing of information, and appropriate handling of both verbal and non-verbal data. Special learning disorders cannot be simply attributed to insufficient education or intellectual impairment; instead, it seems that the root of these disorders lies in genetic and epigenetic factors as well as fundamental psychological processes (Pennington et al., 2019). Specific learning disorders manifest in difficulties in reading, mathematics, and written expression and affect between 5% to 15% of school-age children (Grigorenko et al., 2020). The gender ratio between affected girls and boys may vary between 2:1 and 3:1 (Grigorenko et al., 2020). In most cases, these disorders co-occur with other conditions such as attention-deficit/hyperactivity disorder (ADHD), anxiety disorders, developmental coordination disorder, language disorders, and mood disorders (Margari et al., 2013).

Dysgraphia and specific learning disorders in written expression are terms used to describe individuals who, despite receiving adequate education, do not demonstrate the ability to write commensurate with their cognitive level and age (Chung et al., 2020). The fifth edition of the Diagnostic and Statistical

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Manual of Mental Disorders (DSM-5) does not define specific learning disorders as a separate disorder but places them under the diagnostic category of "specific learning disorder" and considers three characteristics. Thus, the term "impairment in written expression" is used to describe writing-related learning disorders, encompassing issues such as spelling errors, repetitive grammatical mistakes, and deficiencies in clarity and organization (American Psychiatric Association, 2013).

Impairments in writing or written expression can occur individually, but they are often accompanied by reading difficulties and other learning disorders. Depending on the definitions used, approximately 30% to 47% of children with writing difficulties also have reading problems. Additionally, writing difficulties are observed in many neurodevelopmental disorders such as attention-deficit/hyperactivity disorder (ADHD) and autism spectrum disorders, along with issues related to motor coordination (Alsaedi et al., 2020a; Martins et al., 2013; Mayes & Calhoun, 2007). This disorder also shares similarities with developmental coordination disorder (Alsaedi et al., 2020b). Writing-related learning disorders affect an individual's ability to write and organize thoughts on paper using appropriate details, sequencing, sentence structure, and literary form (Fenwick et al., 2016). These difficulties can manifest alongside problems in verbal and visual processing, as well as issues related to motor coordination and executive functioning (Chung et al., 2020).

Writing or written expression is a complex construct, and its successful execution depends on various factors, including phonological awareness, spelling, cognitive and metacognitive skills, and executive functions. To produce a written work, one must align multiple components, from motor skills to coordinating cognitive functions (Ardila & Surloff, 2006; Molitor et al., 2016). Writing is a visual task guided by the writer's eyes. It is also a spatial task involving the organization of text by placing graphic marks on the page. Furthermore, writing often involves translating mental visual and spatial representations into text, and written text can be represented in visual-spatial forms (Olive & Passerault, 2012).

Visual-spatial ability is defined as the capacity to remember, generate, display, and transform symbolic and non-linguistic information (Yılmaz, 2009). Individuals with high visual-spatial abilities tend to have more cognitive resources and greater attention to support their learning (Çöltekin et al., 2018). Studies on the dimensions of visual-spatial writing are scarce, and cognitive patterns of writing only briefly describe mental representations and essential processes. For example, in the Flower and Hayes (1981) cognitive model of writing, writing involves three main cognitive processes/strategies: planning, translating, and reviewing. Writing, in this model, is conceptualized as a purposeful problem-solving process guided by the writer's executive functions. The Berninger and Winn (2006) model is another theoretical framework explaining components of written expression. Changes made in this model

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indicate a deeper understanding of the role of memory and attention in executive functioning. In this model, the components of written expression can be seen as the three vertices of an intersecting triangle: at the lower left corner is transcription, at the top vertex is text generation, and at the lower right corner are executive functions (i.e., supervisory attention, goal setting, planning, reviewing, self-monitoring strategies, and self-regulation). Working memory is situated at the center and actively maintains information during planning, writing, reviewing, and revising tasks (Watson et al., 2016).

Various studies (Berninger et al., 2010; Moll et al., 2016) relate the development of specific writing skills to appropriate working memory performance. Working memory plays a role in maintaining information for goal-directed behavior (Montez et al., 2017). To better understand the role of working memory, conceptual models can be employed. One such model is the McLean and Hitch (1999) multicomponent model of working memory. In this model, working memory is a systemic construct comprised of components related to each other, including a central executive and several subsidiary systems. The central executive is responsible for controlling attention and coordinating various tasks. The second component in working memory is the visuospatial sketchpad, which is involved in maintaining visual images, pictures, and spatial information. The third component is the phonological loop, which plays a role in storing speech-related information such as numbers, words, and sentences. The fourth component is the episodic buffer, which integrates information from both the visuospatial sketchpad and phonological loop and interfaces with long-term memory, providing a cohesive and coordinated role. Kluger, using the Baddeley and Hitch multicomponent model, analyzed the support of different working memory system components in writing. According to this framework, the verbal, visual, and spatial working memory components support the writing process. That is, grammatical encoding, phonological awareness, and spelling rely on working memory (Galbraith et al., 2005; Kellogg et al., 2007).

In this regard, visual-spatial functioning is one of the active components of memory. Alongside storing information, it also performs manipulation and processing functions (Baddeley, 1992). Studies conducted on students with learning disorders have shown evidence of working memory deficits in the transfer and adaptation of visual-spatial memory functioning. These deficits may lead to problems such as reading disorders, short-term verbal memory impairment, and attention and processing speed issues (Jenks et al., 2009). It has also been demonstrated that individuals with writing disorders may likely experience difficulties in processing verbal language and brain visual reasoning centers (Döhla & Heim, 2016). In this regard, the results of the study by Vlachos and Karapetsas (2003) suggest that children with writing disorders may suffer from cognitive problems that go beyond visual-motor skills, affecting visual memory more than visual-spatial motor skills. Evidence suggests that impaired cognitive-executive functions may lead to such disabilities (Pourabdol et al., 2020).

Attention is another crucial variable related to writing and written expression. Attention, in regulating and prioritizing the stimuli processed by the central nervous system, acts as the "gatekeeper" of the mind (Schneider et al., 2012). Erbay (2013) defines attention as an individual's skill to concentrate on their perception and thinking at a particular moment and disregard peripheral stimuli. Cognitive performance, memory, and learning heavily depend on the functioning of attention mechanisms. Fundamental neuroscience research indicates that attention consists of relatively independent subcomponents reliant on distinct neural structures, each serving various functions in everyday behaviors. Brain dysfunction, such as learning disabilities, can lead to various patterns of attentional dysfunction (Estrada-Peña et al., 2004).

Several studies have shown that a child's ability to focus is directly related to academic success and attention problems can also be associated with weak executive functions and behavioral control issues, leading to disruptive behaviors in school. Furthermore, attention problems are often associated with learning disabilities or can coexist with them (Commodari, 2012; Gardner-Neblett et al., 2014). Attention during writing, especially supervisory attention, helps regulate higher-level executive functions during the writing process (Berninger et al., 2012), and children with writing difficulties have been shown to have difficulties in performing supervisory attention tasks (Altemeier et al., 2006; Hooper et al., 2002).

In this regard, Mayes et al. (2000) found in their study on learning disabilities and attention deficit/hyperactivity disorder among students aged 8 to 16 that both learning disabilities and attention deficit/hyperactivity disorder are interlinked and often coexist. Additionally, Amiriani et al. (2010) compared auditory attention in students with learning disabilities and typically developing 7 to 9-year-olds. They concluded that in children with learning disabilities, selective auditory attention is not affected in terms of signal-to-noise ratio, but divided auditory attention appears to be affected due to incomplete development of the central auditory system or central auditory processing disorders.

Another variable that appears to be important in the writing process is cognitive processing speed, which is defined as the ability to process information quickly and is closely related to higher cognitive task performance (Lichtenberger & Kaufman, 2012). In other words, cognitive processing speed refers to the speed at which an individual receives (visually or auditorily) information, comprehends it, and then responds. This means that cognitive processing speed, in terms of receiving data, generating a comparison process, and ultimately altering or maintaining the existing information through cognitive processes in the brain, is defined (Halligan et al., 2002). Learning disabilities are also defined as a

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neurobiological disorder that arises due to abnormal brain function. Due to this brain dysfunction, children with learning disabilities receive and process information differently than typical children. Information processing deficiencies in children with learning disabilities have been identified in areas such as decoding or word recognition, reading comprehension, calculation, mathematical reasoning, spelling, or written expression, as well as in language processing (Policy et al., 2008). Processing speed significantly affects basic writing and written expression skills at different ages (Floyd et al., 2008). Sulaiman et al. (2011) in a study titled "Cognitive Ability Level among Malaysian Children with Learning Disabilities" showed that half of the children with learning disabilities were able to recognize and pronounce words and letters. However, they encountered difficulties in reading and writing the desired words and also in providing examples for shapes that were asked about. Thus, cognitive processing speed is related to an individual's ability to perform rapid and automatic cognitive tasks. Students with slow processing speed spend more time on academic tasks (Alloway, 2012; Schneider & McGrew, 2012).

In conclusion, considering what has been said, writing is one of the complex cognitive activities involving various processes, and it requires the synchronization of higher cognitive levels (language, verbal working memory, and organization) with planning and motor execution. Epidemiological studies show that writing difficulties are one of the most common and debilitating academic problems for all school-age children (Mayes & Calhoun, 2006), and the ability to produce quality written work plays a significant role in academic success (Graham & Perin, 2007). Therefore, identifying factors affecting writing difficulties and differentiating between typical students and students with learning disabilities characterized by writing difficulties will help better understand students' writing problems and provide valuable information on how to design appropriate interventions and education for these students by neuropsychologists, psychologists, and educational specialists.

On the other hand, in comparison to reading and mathematics disorders, relatively few studies have investigated attention, cognitive processing speed, and visual-spatial performance in students with writing difficulties, and this current research is innovative in this regard. Given the aforementioned research gaps, the necessity of this study is doubled. With the information provided above, this study aimed to compare attention, cognitive processing ability, and visual-spatial performance in students with learning disabilities characterized by writing difficulties and typical students. In other words, this study sought to answer the question of whether there is any difference in attention, cognitive processing ability, and visual-spatial performance between typical students and students with learning disabilities characterized by writing difficulties.

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Material and Methods

The research conducted was of an analytical-comparative nature considering the nature of the subject and its objectives. The population of this study consisted of normal male students and students with specific learning disabilities characterized by writing difficulties in the third grade in Tabriz in 2020. To select typical students from public elementary schools in the third district of Tabriz, one school was chosen, and 60 students from the third grade of that school were selected through purposive sampling. The inclusion criteria for typical students were as follows: 1) the absence of any psychiatric disorders, 2) male gender, and 3) willingness to participate in the research. Furthermore, in order to achieve the research objectives, 60 students with specific learning disabilities characterized by writing difficulties were selected as the sample from the learning disabilities centers in the third district of Tabriz using purposive sampling. The inclusion criteria for students with specific learning disabilities characterized by writing difficulties were as follows: 1) diagnosis of specific learning disabilities characterized by writing difficulties by the instructors at the Learning Disabilities Center, 2) the absence of other psychiatric disorders, 3) male gender, and 4) willingness to participate in the research.

The research data were collected using the Conners Neuropsychological Questionnaire (2004), which was completed by teachers in regular schools and instructors at the Learning Disabilities Center.

Instruments

Conners Neuropsychological Questionnaire: This questionnaire, developed by Conners et al. (Epstein et al., 2001), is designed to assess neuropsychological skills in children aged 5 to 12 years. The questionnaire evaluates attention problems, sensory-motor function, language function, executive functions, memory and learning abilities, cognitive processing speed and ability, visual-spatial performance, and academic performance (reading, writing, mathematics) in four spectra (not observed to severe) and is rated on a 0 to 3 scale in the Likert rating system. In this study, to achieve the research objectives, the sub-scales of attention problems (14 items), cognitive processing speed and ability (7 items), and visual-spatial performance (5 items) were used. The internal consistency reliability coefficients in the range of 0.75 to 0.90 and the test-retest reliability coefficient with an eight-week interval from 0.60 to 0.90 have been reported. The construct validity of Conners' forms has been obtained using factor analysis methods, and its discriminant validity has been strongly confirmed by statistically evaluating the questionnaire's ability to differentiate individuals with ADHD from normal individuals and other clinical groups. Jadidi and Abedi (2011) translated and normalized this questionnaire and reported its structural validity as suitable and its reliability using Cronbach's alpha as 0.72. In the present study, the test-retest reliability of this scale was obtained through correlation method in two runs on 30 elementary school children with a three-week interval, which was 0.78.

Results

Table 1 presents descriptive statistics of the research variables. According to Table 1, the mean scores for attention problems (47.63), cognitive processing speed (23.08), and visual-spatial performance problems (14.11) were higher for male students with specific learning disabilities characterized by writing difficulties compared to the mean scores for attention problems (29.06), cognitive processing speed (14.38), and visual-spatial performance problems (7.93) in typical male students without disabilities.

Table 1. Descriptive statistics of research variables

Variable	Group	N	Mean	SD
Attention problems	LD	60	47.63	7.86
	Normal	60	29.06	9.14
Cognitive processing speed	LD	60	23.08	5.18
	Normal	60	14.38	6.56
Visual-spatial performance	LD	60	14.11	3.88
	Normal	60	7.93	3.18

Before using the parametric multivariate analysis, Box's M and Levene tests were employed to meet its assumptions. The results of the Box's M test (Table 2) showed that none of the variables were significant (Box's M = 7.85, F = 1.18, p = 0.460), indicating the homogeneity of the variance-covariance matrices.

Table 2. Results of the Box-M test for testing the homogeneity of variance-covariance matrices

Box's M test	F	p
7.58	1.18	0.46

Furthermore, the results of the Levene test (Table 3) indicated that there were no significant differences in variances among the study variables (P = 0.116 for attention problems, P = 0.252 for cognitive processing speed, and P = 0.112 for visual-spatial performance). Therefore, the assumptions related to homogeneity of variances were satisfied.

Table 3. Results of Levene's test for testing the equality of variances of study variables

Variable	F	DF1	DF2	p
Attention problems	2.53	1	118	0.11
Cognitive processing speed	2.74	1	118	0.12
Visual-spatial performance	2.11	1	118	0.10

Additionally, the results of the multivariate analysis of variance (MANOVA) were conducted to examine group differences, and the results are presented in Tables 4.

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Table 4. Results of Wilks' Lambda

Effect	Test	Value	F	Effect DF	Error DF	p
Group	Wilks lambda	0.59	7.24	3	116	0.001

The results of Wilks' Lambda test (Table 4) showed that there was a significant difference between the two groups in at least one of the research variables. According to the results obtained from the Box's M, Lambda, and Levene tests, follow-up analyses were conducted to investigate the intergroup effects, and the results are presented in Table 5.

Table 5. Results of multivariate analysis of variance for research variables

Variable	SS	DF	MS	F	p
Attention problems	546.017	1	546.017	27.611	0.001
Cognitive processing speed	170.017	1	170.017	7.16	0.001
Visual-spatial performance	14.26	1	14.26	3.86	0.001

As Table 4 indicates, the calculated F-values were significant for the variables of attention problems ($F = 7.16$, $p < 0.05$), visual-spatial performance ($F = 3.861$, $p > 0.05$) and cognitive processing speed ($F = 27.61$, $p < 0.001$), showing a meaningful difference between the two groups.

Discussion

The aim of this study was to compare attention problems, cognitive processing speed, and visual-spatial performance between male students with and without specific learning disabilities in writing from first to third grade in the Tabriz. The findings indicated that there were differences between the two groups of students in attention problems, cognitive processing speed, and visual-spatial performance.

The results concerning the differences between the two groups of students in attention problems are consistent with the findings of previous studies (Altemeier et al., 2006; Amiriani et al., 2010; Garcia et al., 2007; Hooper et al., 2002; Mayes et al., 2000). Mayes et al. (2000) believe that learning problems and attention deficits are interrelated and often coexist. Amiriani et al. (2010) demonstrated significant differences in auditory attention between students with learning disabilities and typical students, which may be attributed to central auditory system disorders. Garcia et al. (2007) concluded that selective auditory attention is significantly reduced in children with learning disabilities compared to the typical group. These findings can be explained from the perspective of Estrada-Peña et al. (2004), who consider attention as the mind's gatekeeper that regulates and prioritizes stimuli processed by the central nervous system, thus emphasizing the strong connection between learning and the functioning of attention mechanisms. Additionally, using Berninger et al. (2012) perspective, attention during writing, especially

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supervisory attention, helps regulate higher-level executive functions during the writing process. Students with learning disabilities in writing may have difficulty paying precise attention to details or may make mistakes in schoolwork, work, or other activities due to this attention deficit, resulting in lower academic performance.

The findings related to the differences between the two groups of students in cognitive processing speed are in line with some of the results of earlier studies (Berninger et al., 2010; Floyd et al., 2008; Nevo & Breznitz, 2011; PLAZA, 2003; Sulaiman et al., 2011). For example, Floyd et al. (2008) emphasized that processing speed influences fundamental writing and expressive writing skills. PLAZA (2003) showed that naming speed is one of the predictors of phonological awareness, which can be used in diagnosis and intervention. In explaining the study's findings, it can be said that processing speed is an individual's ability to perform rapid and automatic cognitive tasks ((Floyd et al., 2008). Students with lower processing speed spend more time on academic tasks (Alloway, 2012; Schneider & McGrew, 2012). Additionally, processing speed interacts with other cognitive domains and negatively affects a student's ability to respond quickly, retrieve information from long-term memory, and remember tasks to be performed within a specified time frame (Braaten & Willoughby, 2014). Faster processing speed allows for greater allocation of attention to higher-level tasks, enabling cognitive and academic success (Travers et al., 2014). Therefore, students with writing disabilities may have lower academic success due to deficits in processing speed.

The findings related to the differences between the two groups of students in visual-spatial performance are consistent with some of the results of studies by Swanson and Jerman (2006), Rousselle and Noël (2007), and Vlachos and Karapetsas (2003). Swanson and Jerman (2006) and Rousselle and Noël (2007),demonstrated that children with learning disabilities have lower performance in active memory, name memory, faces, and especially visual-spatial and long-term memory compared to typical students. The results of Doehla et al. (2018) indicated that, in addition to phonological processing skills, auditory skills and visual-perceptual functions also affect phonemic awareness, allowing for the division of children with writing disabilities into two separate clusters: those with auditory deficits and those with deficits in cellular visual functions. Vlachos and Karapetsas (2003) findings suggest that children with writing disabilities may suffer from cognitive problems that affect visual-motor memory more than visual-motor skills. Moreover, Banfi et al. (2017)) indicated that visual-spatial attention is essential for processing written language.

To explain the difference in visual-spatial performance between students with writing disabilities and typical students, Kellogg et al. (2013) model can be considered. This model analyzes various components of working memory systems in the writing process, stating that phonological, visual, and spatial components of working memory support the writing and sentence generation process. Thus, in the writing process of students with learning disabilities in writing, necessary support from working memory components, especially visual-spatial memory, may not occur, meaning they do not have the cognitive resources and attention needed to support learning (Çöltekin et al., 2018). Therefore, it is observed that visual-spatial performance is one of the components of active memory that, along with storing information, plays a role in grammatical encoding, phonological recognition, or spelling (Galbraith et al., 2005; Kellogg et al., 2007).

This study faced limitations, including a small sample size and the fact that the participants were all male. Therefore, caution should be exercised when generalizing the results. In summary, based on this study, it can be concluded that learning disability in writing is related to problems in visual-spatial performance, attention, and cognitive processing speed. Given this, it is suggested that interventions related to these areas be included in the educational and therapeutic programs for students with learning disabilities in writing.

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