

Visual-motor Integration and Academic Achievement in Children with Specific Learning Disabilities: A Cross-sectional Study

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ABSTRACT

Introduction: Children with Specific Learning Disabilities (SLD) often exhibit difficulties beyond academic skills, particularly in Visual Perception (VP), Motor Coordination (MC), and Visual-motor Integration (VMI), which can adversely affect classroom performance.

Aim: To examine the influence of demographic variables on VP, MC, and VMI, and to explore their relationship with academic achievement in children with SLD.

Materials and Methods: This cross-sectional study included 120 children aged 8-15 years diagnosed with SLD, recruited from schools and clinical settings in Kolkata, West Bengal, India. Standardised assessments were used to evaluate VP, MC, and VMI. Academic performance in English and Mathematics was obtained from school records. Independent samples t-tests, One-way Analysis of Variance (ANOVA), and Pearson correlation analyses were performed using Statistical Package for the Social Sciences

(SPSS) Statistical significance was set at p-value <0.05 with p-value <0.01 and 0.001 indicating higher levels of significance.

Results: Age showed a statistically significant association with VMI ($F=2.43$, $p\text{-value}=0.002$), but not with VP or MC. Gender and family type did not significantly influence any visuomotor domain. Geographical location showed a significant difference only for MC, with rural children performing better than urban children ($t=-2.34$, $p\text{-value}=0.002$). Significant positive correlations were observed between visuomotor abilities and academic achievement in English and Mathematics, with VP showing the strongest association with English performance ($r\text{-value}=0.74$, $p\text{-value}<0.001$).

Conclusion: Visuomotor abilities are strongly associated with academic achievement in children with SLD. Assessment of VP, MC, and VMI should be included in routine evaluation, and early targeted intervention may support better classroom participation and learning outcomes.

Keywords: Child, Educational measurement, Learning, Neurodevelopmental disorders, Psychomotor performance

INTRODUCTION

Specific Learning Disabilities (SLD) are neurodevelopmental disorders characterised by persistent difficulties in reading, writing, and mathematics despite adequate intelligence and educational opportunity [1]. In addition to core academic deficits, children with SLD frequently demonstrate impairments in underlying neurocognitive processes such as Visual Perception (VP), Motor Coordination (MC), and Visuo Motor Integration (VMI) [2-4].

Visuo Motor Integration (VMI) refers to the ability to coordinate visual perceptual input with appropriate motor output [2]. This skill is essential for classroom tasks including handwriting, copying from the board, drawing, and spatial alignment in mathematics [5,6]. Research consistently suggests that children with SLD show greater difficulty in integrating visual and motor processes than in isolated VP alone, highlighting the integrative nature of their learning challenges [4,7-11].

Studies in typically developing children demonstrate that visuomotor abilities improve with maturation [12-15]. However, findings from clinical populations suggest variations in developmental patterns, indicating delayed or inefficient integration of perceptual and motor processes [8,14,16,17]. Environmental and cultural contexts have also been associated with visuomotor performance [4,12,14,16], highlighting the role of educational exposure and participation in activities. Research examining gender differences has produced inconsistent findings, with some studies reporting differences [3,18,19] and others demonstrating no significant variation [17,20-22] suggesting that neurological and functional characteristics may play a greater role than demographic variables alone.

Despite substantial evidence on the development of VMI in typically developing children, most existing research has been conducted in Western populations [20,23]. There is a paucity of research examining how age and gender influence VMI in children with SLD in the Indian context, where educational systems, cultural practices, and environmental exposures differ significantly. Furthermore, although VP, MC, and VMI have been individually associated with academic performance, limited research has explored the interrelationship among these domains specifically in children with SLD [8,10,24]. Given that SLD is characterised by atypical neurodevelopment, the pattern and severity of these deficits may differ from those observed in typically developing peers.

Addressing these gaps is essential for developing contextually relevant assessment and intervention strategies for children with SLD. Understanding how visuomotor abilities vary with age and gender, and how they interact with underlying perceptual and motor processes, can contribute to more targeted educational planning and therapeutic approaches. Therefore, the present study aimed to examine VMI and its associated factors in children with SLD, in order to generate evidence that supports improved identification, intervention, and academic outcomes in this population. This study is a part of a larger research work on sensory processing, VMI and academic performance of Children with SLD.

Objectives

1. To examine age-related differences in VP, MC, and VMI in children with SLD.

- To analyse the association of demographic variables (age, gender, geographical location, and family type) with visuomotor abilities.
- To determine the relationship between VP, MC, VMI, and academic performance.

Hypotheses

H1: VP, MC, and VMI will show significant positive correlations with academic achievement in children with SLD.

H2: VMI will differ across age groups, whereas gender and family type will not show significant differences in visuomotor abilities.

MATERIALS AND METHODS

This cross-sectional study was conducted among school-going children diagnosed with SLD in Kolkata, West Bengal, India, after approval from the Doctoral Research Committee of MAHER (MAHER/IEC/PhD/143). Data were collected from mainstream schools and clinical settings and analysed between June 2024 and January 2026.

Inclusion criteria: A total of 120 children aged 8-15 years participated in the study. Diagnosis of SLD was confirmed based on clinical records and DSM-5 criteria [11].

Exclusion criteria: Children with co-existing neurological or developmental disorders (autism spectrum disorder, attention-deficit/hyperactivity disorder, intellectual disability) and those with uncorrected sensory impairments were excluded from the study.

Sample size estimation: Sample size was determined for correlation analysis using a moderate effect size ($r=0.30$), alpha level of 0.05, and statistical power of 0.80. The minimum required sample was 84 participants; therefore, 120 children were included to improve statistical reliability.

Measures: VMI, VP, and MC were assessed using the Beery-Buktenica Developmental Test of VMI, Sixth Edition (Beery VMI-6) (Beery and Beery, 2010). The test was administered in a paper-and-pencil format and scored according to the standardised manual guidelines.

The instrument comprises three subtests:

- Visual-Motor Integration (VMI):** Participants copy a series of increasingly complex geometric forms, measuring the coordination of visual perceptual input with fine motor output.
- Visual Perception (VP):** Participants complete matching tasks that require visual discrimination and analysis, minimising motor involvement.
- Motor Coordination (MC):** Participants trace forms within boundaries under timed conditions, assessing fine motor control.

Higher scores in each test indicates better performance with the maximum possible score is 30 and minimum is zero. The Beery VMI-6 demonstrates strong psychometric properties, including internal consistency coefficients greater than 0.80 and well-established construct validity.

Academic performance: Academic performance was obtained from school records based on examination percentage scores in English and Mathematics.

Study Procedure

After obtaining institutional permission and parental consent, children were assessed individually in a quiet room within the school premises. Demographic information was recorded using a structured data sheet. Each assessment session lasted approximately 30-45 minutes and was administered according to standardised procedures described in the test manual. All assessments were conducted by the investigator under uniform conditions, with the support of class teachers.

STATISTICAL ANALYSIS

Data were analysed statistically. Descriptive statistics were calculated for demographic and study variables. One-way ANOVA was used to examine age-group differences. An independent samples t-test was used to compare gender, geographical location, and family type. Pearson correlation coefficient was used to determine relationships between VP, MC, VMI, and academic achievement. Statistical significance was set at p-value <0.05 with $p<0.01$ and 0.001 indicating higher levels of significance.

RESULTS

The study included 120 children aged 8-15 years, comprising 86 boys (71.7%) and 34 girls (28.3%). Most participants were from urban areas (106, 88.3%) and nuclear families (86, 71.7%). Birth order distribution showed the majority were the youngest children (71, 59.2%) [Table/Fig-1].

Variable	Category	n (%)
Gender	Male	86 (71.7)
	Female	34 (28.3)
Age (years)	8	15 (12.5)
	9	18 (15.0)
	10	17 (14.2)
	11	12 (10.0)
	12	10 (8.3)
	13	14 (11.7)
	14	18 (15.0)
	15	16 (13.3)
Birth order	Single	11 (9.2)
	Youngest	71 (59.2)
	Middle	30 (25.0)
	Eldest	8 (6.7)
Location	Urban	106 (88.3)
	Rural	14 (11.7)
Family type	Joint	34 (28.3)
	Nuclear	86 (71.7)

[Table/Fig-1]: Demographic characteristics of participants (N=120).

There were no significant gender differences in VP, MC, or VMI (p -value >0.05) [Table/Fig-2].

Variable	Gender	Mean±SD	t (df=118)	p-value
Visual Perception (VP)	Male	19.55±5.21	0.83	0.39
	Female	18.62±5.60		
Motor Coordination (MC)	Male	15.06±5.59	-0.30	0.76
	Female	15.39±5.24		
Visual Motor Integration (VMI)	Male	15.04±4.92	-0.75	0.46
	Female	15.76±4.35		

[Table/Fig-2]: Gender differences in visuomotor abilities. p -value <0.05 ; statistically significant

Age-group comparison showed significant differences only in VMI, while VP and MC did not differ significantly across age groups [Table/Fig-3]. The variation observed in VMI reflects differences in performance across age groups rather than a consistent decline with age, possibly due to increasing task complexity and higher age-related performance expectations.

Children from rural areas demonstrated significantly higher MC scores than urban children. No differences were observed for VP or VMI [Table/Fig-4].

No significant differences in visuomotor abilities were observed between children from joint and nuclear families [Table/Fig-5].

Age group	Visual perception (VP) (Mean±SD)	p-value	Motor coordination (MC) (Mean±SD)	p-value	Visual-motor Integration (VMI) (Mean±SD)	p-value
8	20.67±4.40	0.87	17.87±5.29	0.07	16.23±4.83	0.002*
9	20.00±5.34		16.08±7.32		16.53±5.31	
10	19.24±6.02		12.03±4.77		12.35±4.06	
11	17.50±6.22		17.13±5.80		18.04±5.07	
12	19.80±2.53		14.05±3.39		16.60±3.70	
13	18.36±5.64		13.93±4.99		13.29±3.73	
14	19.33±5.99		14.64±4.83		14.89±5.34	
15	19.00±5.34		15.78±4.64		15.13±3.60	
Variable				F	p-value	
Visual Perception (VP)				0.45	0.87	
Motor Coordination (MC)				1.92	0.07	
Visual-Motor Integration (VMI)				2.43	0.002*	

[Table/Fig-3]: Age-group differences in visuomotor abilities (N=120).

*Significant at p-value <0.05

Variable	Location	Mean±SD	t (df=118)	p-value
Visual Perception (VP)	Urban	19.16±5.45	0.70	0.49
	Rural	20.21±4.14		
Motor Coordination (MC)	Urban	14.74±5.32	-2.34	0.002*
	Rural	18.32±5.78		
Visual-Motor Integration (VMI)	Urban	15.19±4.72	-0.36	0.72
	Rural	15.68±5.19		

[Table/Fig-4]: Comparison based on geographical location.

*Significant at p-value <0.05

Variable	Family type	Mean±SD	t (df=118)	p-value
Visual Perception (VP)	Joint	20.09±5.03	1.04	0.30
	Nuclear	18.97±5.42		
Motor Coordination (MC)	Joint	14.18±4.91	-1.24	0.22
	Nuclear	15.55±5.66		
Visual-motor Integration (VMI)	Joint	15.21±4.45	-0.06	0.95
	Nuclear	15.26±4.90		

[Table/Fig-5]: Comparison based on family type.

Significant {English (53.55±16.49), Math (48.80±17.16)} positive correlations were observed between visuomotor abilities and academic achievement. The VP showed the strongest relationship with English performance, while MC and VMI demonstrated moderate correlations with both English and Mathematics [Table/Fig-6].

Variables	VP	MC	VMI	English	Maths
Visual Perception (VP)	1				
Motor Coordination (MC)	0.38*	1			
Visual-motor Integration (VMI)	0.31*	0.76**	1		
English	0.74**	0.38*	0.26*	1	
Mathematics	0.49**	0.42**	0.36**	0.59**	1

[Table/Fig-6]: Correlation between VMI and academic achievement (N=120).

*p-value <0.01 **p-value <0.001

DISCUSSION

The present study examined demographic differences and academic relationships of VP, MC and VMI in children with SLD. The findings indicate that visuomotor abilities are correlated with academic performance, with age differences observed only in VMI, while gender and family type showed no significant differences. MC differed by geographical location and all visuomotor domains demonstrated significant correlations with English and Mathematics achievement.

Significant age-group differences were observed only in VMI, whereas VP and MC did not vary significantly. This suggests that integrative perceptual-motor abilities continue to develop during later school years in children with SLD. Studies in typically developing children report progressive improvement of VMI with maturation [12-15], while research in clinical populations indicates delayed integration of perceptual and motor processes [8,14,16,17]. These findings support the view that integration of visual and motor systems develops later than isolated perceptual or motor abilities [15]. Further, the observed variation in VMI scores across age groups, contrary to typical developmental trends, may reflect the atypical neurodevelopmental trajectory associated with SLD. As task complexity and academic demands increase with age, underlying deficits in VMI may become more evident. Reduced practice, academic difficulties, and possible cohort effects inherent in cross-sectional designs may further explain these findings.

No significant gender differences were observed in VP, MC, or VMI. Previous literature has reported inconsistent findings, with some studies showing sex differences [3,18,19] and others reporting minimal variation [17,20-22]. The present findings support the latter and suggest that neurodevelopmental characteristics associated with SLD may be more relevant than gender-related variation.

Similarly, family type was not associated with visuomotor abilities, indicating that perceptual-motor characteristics in SLD are more closely related to neurodevelopmental functioning than family structure.

The MC was better in rural children as compared to urban children, whereas VP and VMI did not differ between the two groups. Environmental opportunities such as physical activity exposure and play participation may contribute to differences in MC. Previous studies indicate that environmental and participation factors are associated with motor development [4,12,14,16]. However, the absence of difference in VMI suggests that integrative processing depends more on neurocognitive mechanisms than activity exposure alone.

All visuomotor domains demonstrated significant positive correlations with English and Mathematics achievement. The VP showed the strongest relationship with English performance, consistent with the role of visual discrimination and symbol recognition in reading and written language [9,20,25]. MC demonstrated moderate relationships with academic performance, reflecting the importance of fine motor control for handwriting and classroom task execution [5,25,26]. VMI showed weaker but significant correlations with academic achievement. VMI represents the coordination of perceptual input and motor output required for copying, spatial alignment, and written expression [2,9,20].

A strong relationship was observed between MC and VMI, supporting the integrated nature of perceptual-motor functioning [15,17]. Limitations in either perceptual or motor processes may therefore affect classroom participation in children with SLD.

The findings indicate that academic difficulties in children with SLD are associated not only with academic skill deficits but also with perceptual-motor functioning. Assessment of VP, MC, and VMI may help identify functional barriers affecting classroom participation. Screening of visuomotor abilities may assist in planning targeted occupational therapy strategies focusing on handwriting, visual tracking, and spatial organisation tasks [5].

Limitation(s)

The cross-sectional design limits causal interpretation and developmental inferences. The sample was drawn from a single region, which may affect generalisability. Academic performance was based on school examination records that may vary in standardisation across settings.

Future studies may use longitudinal designs with larger and more diverse samples and include neuropsychological measures to better

understand visuomotor functioning in children with SLD. Exploration of factors such as socio-economic status, executive functioning, and language abilities may further clarify individual differences.

CONCLUSION(S)

The VP, MC, and VMI were significantly associated with academic achievement in children with SLD. Age-group differences were observed only in VMI, while gender and family type showed no significant differences. MC differed by geographical location and was better among rural children. Among the visuomotor domains, VP showed the strongest relationship with English performance. These findings indicate that academic performance in children with SLD is related not only to scholastic abilities but also to perceptual-motor functioning. Assessment of visuomotor abilities may therefore assist educational planning and rehabilitation strategies.

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