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**DEVELOPMENTAL PATTERNS OF VISUAL PERCEPTION, MOTOR  
COORDINATION, AND VISUAL-MOTOR INTEGRATION IN CHILDREN  
WITH AUTISM SPECTRUM DISORDER - A PILOT STUDY**

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**ABSTRACT**

This pilot study examined the developmental trajectories of visual perception, motor coordination, and visual-motor integration (VMI) in children with Autism Spectrum Disorder (ASD) aged 6-11 years. Objectives included examining age-related changes, assessing gender differences, and investigating correlations among these domains. Using purposive sampling, 50 children diagnosed with ASD were recruited. The Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery VMI, Long Form) was administered to evaluate VMI, along with supplementary standardized tests for visual perception and motor coordination. Results indicated significant age-related improvements in motor coordination and VMI, suggesting developmental progression. No significant gender differences were observed. Significant positive correlations were found among all three domains, with the strongest association between motor coordination and VMI. These findings suggest that VMI in children with ASD develops along an age-related trajectory independent of gender. The study highlights the importance of targeting VMI in intervention planning to support motor skill development, providing preliminary insights for designing tailored rehabilitation strategies.

**Keywords: Autism Spectrum Disorder, visual perception, motor coordination, visual-motor integration, developmental patterns**

## INTRODUCTION

Visual–motor integration (VMI) is a crucial developmental skill frequently evaluated in children, particularly in the context of handwriting and academic readiness. It is defined as the coordination of visual, perceptual, and fine motor abilities [1]. Deficits in VMI are linked to slow, uncoordinated, and illegible handwriting [2]. Children with Autism Spectrum Disorder (ASD) consistently demonstrate impairments in visual–motor integration compared to typically developing peers [3, 4]. Research has shown that these difficulties are often more pronounced than isolated fine motor deficits, indicating broader challenges in perceptual–motor integration [5, 6].

Visual perception is defined as the brain's ability to receive, organise, and interpret visual information, it shows atypical patterns in ASD. While enhanced detail-focussed processing and strengths in local visual discrimination have been reported, difficulties are frequently observed in facial recognition, imitation and socially relevant visual processing [7-11].

Visuospatial perception in ASD presents a heterogeneous profile. Children with ASD often perform adequately or even superiorly on static visuospatial tasks; however, reduced accuracy is evident in tasks involving dynamic motion perception and global visual processing<sup>12-15</sup>. These

perceptual differences are thought to contribute to difficulties in motor imitation and coordination, both of which play a critical role in motor learning [16].

Visual–motor integration underlies many motor difficulties observed in ASD by influencing motor planning, execution, and eye–hand coordination. Inefficient integration of visual and motor inputs can impair fine motor precision and coordinated movement [17, 18]. The Beery–Buktenica Developmental Test of Visual–Motor Integration (Beery VMI) is one of the most widely used standardized tools for assessing these skills and demonstrates strong psychometric properties across clinical populations [19].

Evidence consistently indicates that children with ASD perform significantly poorer on the Beery VMI and its supplemental tests compared to typically developing children [17, 19, 20]. Occupational therapists therefore rely heavily on standardized assessments such as the Beery VMI to evaluate perceptual–motor functioning and guide intervention planning [21].

Collectively, existing evidence highlights the need for a developmental and integrative examination of perceptual and motor domains in children with ASD. In addition, previous research has reported inconsistent findings regarding gender-related differences in motor and visual–motor

functioning in children with ASD, highlighting the need for further examination of gender effects [22-24]. Specifically, the interrelationships among visual perception, motor coordination, and visual-motor integration in school-aged children with ASD have not been sufficiently examined within a single developmental framework. A deeper understanding of these interrelationships may clarify mechanisms underlying motor challenges and guide intervention strategies. Middle childhood (6–11 years) represents a critical period for refining fine motor skills, visual-motor integration, and academic-related motor demands such as handwriting, copying, and classroom participation. Despite its clinical importance, limited empirical evidence is available on how visual perception, motor coordination, and visual-motor integration interacts and evolves across this developmental period in children with ASD.

### Objectives of the study

- To assess visual perception, motor coordination, and VMI in children with ASD aged 6-11 years.
- To assess visual perception, motor coordination, and VMI in children with ASD across gender.
- To examine the associations between motor skills, visual perception, and

VMI among school-aged children with ASD.

## MATERIALS AND METHODS

### Participants

Fifty children diagnosed with ASD were recruited for the study using purposive sampling. Inclusion criteria required that participants (i) had a primary diagnosis of ASD, (ii) possessed an intelligence level classified as low average or average, (iii) were able to comprehend simple verbal instructions such as the word “ball,” (iv) demonstrated the ability to use a pencil for writing on paper, and (v) were enrolled in a regular school affiliated with the State Board, Central Board, or Indian Council. Children who did not meet these criteria were excluded.

### Tools Used

The Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition (Beery VMI), was employed<sup>19</sup>. This standardized test measures the coordination of visual perception and fine motor control and includes three subtests:

#### Visual-Motor Integration (VMI) Subtest:

Participants copied 30 geometric forms of increasing complexity. Each item was scored as correct (1) or incorrect (0), with testing discontinued after three consecutive errors.

#### Visual Perception (VP) Subtest:

Participants identified a target figure from distractors within a 3-minute limit. Scoring

was based on the total number of correct responses.

### **Motor Coordination (MC) Subtest:**

Participants traced within the boundaries of increasingly complex shapes within 5 minutes. Accuracy was scored, with partial credit awarded for near-accurate responses. The Beery VMI demonstrates strong psychometric properties with internal consistency (0.81–0.82), test–retest reliability (0.84–0.88), and inter-rater reliability (0.93–0.98)

### **Procedure**

Participants were screened using the inclusion criteria. Informed consent was obtained from parents or guardians, and assent was sought from the children. Beery VMI was administered individually in a quiet, distraction-free environment within the participants' school using standardized protocols. Each session lasted approximately 20 - 25 minutes. Following completion, participants and their families were debriefed.

### **Ethical Considerations**

The study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki. Informed consent was obtained from parents or guardians before participation.

### **Statistical Analysis**

Data were analysed using descriptive statistics to summarize participant characteristics and test scores. Independent t-tests were used to examine gender differences, and one-way ANOVA assessed age-related differences. Pearson's correlation coefficient was applied to investigate associations among visual perception, motor coordination, and VMI. A p-value < 0.05 was considered statistically significant [25].

### **RESULTS**

The distribution of visual perception, motor coordination, and visual-motor integration was assessed for normality using QQ plots (**Figure 1**), histograms (**Figure 2**), and the Shapiro–Wilk test (**Table 1**). The box plot (**Figure 3**) indicates that an outlier in Visual Perception, while no outliers were observed for Motor Coordination or Visual-Motor Integration.

Shapiro–Wilk test results indicated that Motor Coordination ( $W = 0.96$ ,  $p = 0.16$ ) and Visual–Motor Integration ( $W = 0.97$ ,  $p = 0.29$ ) were normally distributed. Visual Perception showed a slight deviation from normality ( $W = 0.95$ ,  $p = 0.03$ ).

**Table 1: Normality check and Descriptive analysis of visual perception, motor coordination, and visual-motor integration of school going- children with autism (N=50)**

Variables	Mean	SD	Shapiro-Wilk	df	sig
Visual Perception	19.08	6.04	0.95	50	0.03
Motor Coordination	14.32	6.73	0.96	50	0.16
Visual-Motor Integration	13.86	6.02	0.97	50	0.29

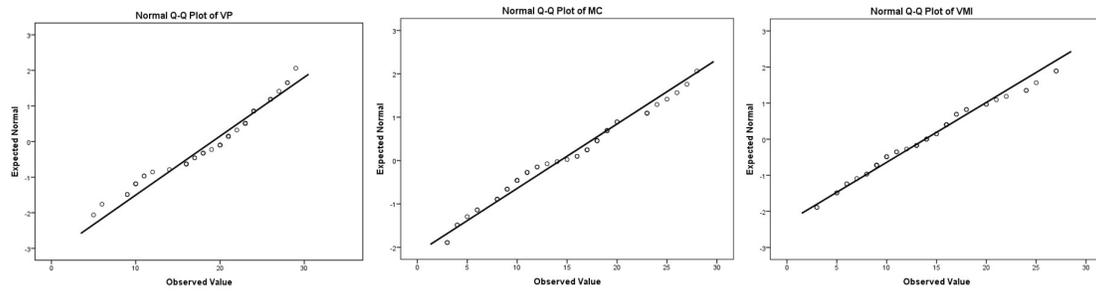


Figure 1: QQ plots

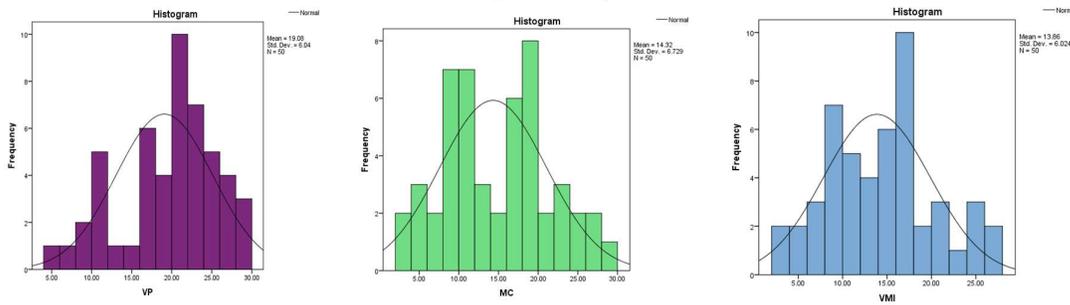


Figure 2: Shows the histogram of visual perception, motor coordination and visual-motor integration of school-going children with autism

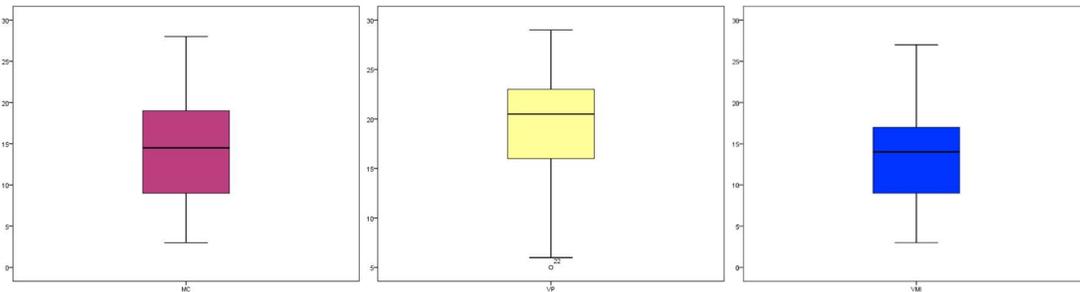


Figure 3: Shows the box plot of visual perception, motor coordination, and visual-motor integration of school-going children with autism

### Age-Related Differences in Visual Perception, Motor Coordination, and Visual-Motor Integration

Table 2 presents the mean scores, standard deviations, and one-way ANOVA results for Visual Perception (VP), Motor Coordination (MC), and Visual-Motor Integration (VMI) across age groups (6–11 years) in school-going children with ASD (N = 50).

Mean Visual Perception scores ranged from 16.5 in 10-year-olds to 23.3 in 11-year-olds.

However, the differences across age groups were not statistically significant ( $F = 1.77, p = 0.14$ ). This finding indicates that visual perception does not vary significantly across the age range of 6–11 years in this sample, suggesting relative stability of visual-perceptual abilities during middle childhood.

Motor Coordination scores showed a statistically significant age-related difference ( $F = 2.94, p = 0.02$ ). Younger

children demonstrated lower motor coordination scores (6 years: M = 11.3, SD = 6.4), whereas older children exhibited higher performance, with the highest mean observed in 11-year-olds (M = 23.8, SD = 4.9). This result indicates a significant improvement in motor coordination with increasing age.

Visual–Motor Integration scores also differed significantly across age groups (F = 3.88, p = 0.01). Younger children scored lower on VMI (6 years: M = 10.21, SD = 4.89) compared to older children, with the highest scores observed in 11-year-olds (M = 20.5, SD = 6.03). This pattern reflects a clear developmental progression in visual–motor integration across middle childhood.

Table 2: Mean, standard deviation, and ANOVA results of VP, MC, and VMI across age groups among school-going children with ASD (N = 50)

Variables	Age (in Years)	N	Mean	Std. Deviation	F-value (df=5,44)	P-value
visual perception	6	19	17.2	6.5	1.77	0.14
	7	9	17.9	5.6		
	8	9	21.9	5.6		
	9	5	22.2	5.2		
	10	4	16.5	4.7		
	11	4	23.3	4.1		
motor coordination	6	19	11.3	6.4	2.94*	0.02
	7	9	14.9	4.9		
	8	9	15.8	6.7		
	9	5	14.4	4.3		
	10	4	14.8	8.6		
	11	4	23.8	4.99		
visual-motor integration	6	19	10.21	4.89	3.88**	0.01
	7	9	15.1	3.9		
	8	9	17	6.1		
	9	5	15.2	5.3		
	10	4	13	7.4		
	11	4	20.5	6.03		

\*p<0.05, \*\*p<0.01

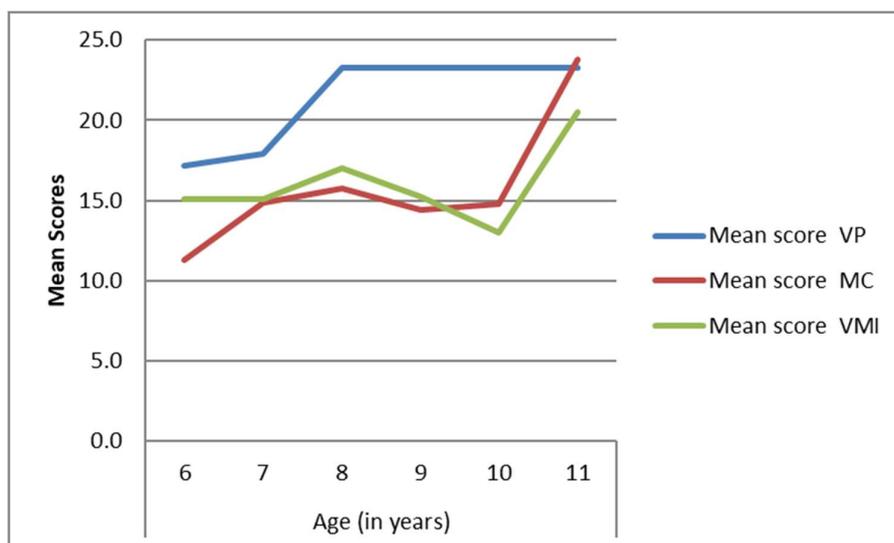


Figure 4: Illustrates the mean scores of Visual Perception (VP), Motor Coordination (MC), and Visual–Motor Integration (VMI) across different age groups (6–11 years) in school-going children with ASD

Post-hoc comparisons using the Least Significant Difference (LSD) test were conducted for Motor Coordination and Visual–Motor Integration.

No statistically significant differences were observed in Visual Perception scores across age groups, as all p-values exceeded 0.05. A borderline difference was noted between the age group of 6 and 8 year children (p = 0.051).

In Motor Coordination, 11-year-olds scored significantly higher than 6-year-olds (p =

0.001), 7-year-olds (p = 0.021), 8-year-olds (p = 0.036), 9-year-olds (p = 0.028), and 10-year-olds (p = 0.044), indicating marked improvement by late childhood.

For Visual–Motor Integration, 11-year-olds demonstrated significantly higher scores than 6-year-olds (p = 0.001). Significant improvements were also observed between 6- and 7-year-olds (p = 0.027) and between 6- and 8-year-olds (p = 0.003). The difference between 10- and 11-year-olds approached significance (p = 0.051).

**Table 3: Mean, standard deviation, and independent t-test results of VP, MC and VMI across gender of school-going children with ASD (N = 50)**

Variables	Gender	N	Mean	Std. Deviation	t-Test (df=48)	p-value
Visual Perception	Male	37	19.43	6.08	0.69	0.49
	Female	13	18.08	6.05		
Motor Coordination	Male	37	14.24	6.73	-0.14	0.89
	Female	13	14.54	7.01		
Visual-Motor Integration	Male	37	13.59	6.11	-0.52	0.60
	Female	13	14.62	5.94		

Note: SD = Standard Deviation; df = Degrees of Freedom; p < 0.05 = statistically significant

As shown in **Table 3**, no statistically significant gender differences were observed in Visual Perception (t = 0.69, p = 0.49), Motor Coordination (t = -0.14, p = 0.89), or Visual–Motor Integration (t = -0.52, p = 0.60). These findings indicate that

male and female children with ASD performed comparably across all three domains, suggesting that gender did not significantly influence visual-perceptual, motor coordination, or visual–motor integration abilities in the present sample.

**Table 4: Pearson correlation coefficients among visual perception, motor coordination, and visual–motor integration in school-going children with ASD (N = 50)**

Variables	Visual Perception	Motor Coordination	Visual-Motor Integration
Visual Perception	1		
Motor Coordination	0.40**	1	
Visual-Motor Integration	0.28*	0.71**	1

Note: \*p < 0.05 (significant); \*\*p < 0.01 (highly significant).

As presented in **Table 4**, a moderate positive correlation was observed between Visual Perception and Motor Coordination (r = 0.40, p < 0.01), indicating that

improvements in visual-perceptual abilities are associated with better motor coordination. However, the strength of this relationship suggests that additional factors

may also contribute to motor coordination performance.

A weak to moderate positive correlation was found between Visual Perception and Visual–Motor Integration ( $r = 0.28$ ,  $p < 0.05$ ), suggesting that while visual perception contributes to VMI performance, it does not independently determine visual–motor integration. This indicates the involvement of other contributing factors such as fine-motor control and cognitive processing.

In contrast, a strong and statistically significant correlation was identified between Motor Coordination and Visual–Motor Integration ( $r = 0.71$ ,  $p < 0.01$ ). This finding suggests that children with better motor coordination tend to demonstrate superior visual–motor integration skills, highlighting the critical role of fine-motor precision and motor control in effective visual–motor integration.

## DISCUSSION

This study examined visual perception (VP), motor coordination (MC), and visual–motor integration (VMI) in children with ASD across age and gender, and explored the interrelationships among these domains.

### Age-Related Differences in Visual Perception, Motor Coordination, and Visual–Motor Integration

The findings indicated significant age-related improvements in MC and VMI, with notable increase by 11 years of age. Visual

perception, in contrast, remained relatively stable across the 6–11-year age range. These results align with previous literature demonstrating that motor planning, fine motor precision, and sensorimotor integration continue to mature through late childhood and early adolescence [16, 20].

Older children demonstrated higher MC and VMI scores, suggesting that these skills improve with age due to neurological maturation, repeated practice, and exposure to structured motor activities [17, 27, 28]. These findings are consistent with evidence that fine motor and VMI abilities develop progressively across childhood and adolescence [19]. In addition, normative data from older adolescents suggest that VMI maturation may extend beyond middle childhood [18].

The stability of visual perception suggests early maturation of basic perceptual abilities, consistent with studies reporting that foundational visual processing develops earlier than higher-order motor integration [12, 13]. Neurodevelopmental evidence indicates that myelination and cortical maturation in parietal and occipital regions continue into late childhood, facilitating improved motor planning, hand–eye coordination, and VMI performance [27, 29]. Additionally, improvements in executive functions such as attention, working memory, and cognitive flexibility further contribute to enhanced motor

precision required for successful VMI task performance<sup>28</sup>.

Structured interventions and repeated practice can support meaningful improvement in motor skills among children with ASD, despite common delays [16, 20].

### **Gender Differences in Visual Perception, Motor Coordination, and Visual–Motor Integration**

No significant gender differences were observed in VP, MC, or VMI, suggesting that male and female children with ASD demonstrate comparable developmental trajectories across these domains. These findings align with previous research reporting minimal or inconsistent gender effects on fine motor and visual–motor skills in neurodevelopmental populations [29, 30]. Although, some studies have reported sex related differences in motor learning, with males showing greater variability in motor performance and females demonstrating superior fine motor precision during certain developmental periods [29, 30], these effects appear to be modest and content dependent. The current findings suggests that perceptual–motor development in ASD is predominantly influenced by neurodevelopmental and experiential factors rather than gender, supporting intervention approaches that do not require gender-specific modifications [29, 30].

### **Associations Among Visual Perception, Motor Coordination, and Visual–Motor Integration**

The study found a strong positive correlation between MC and VMI, indicating that better motor coordination is closely associated with enhanced visual–motor integration. This aligns with previous research highlighting the importance of fine motor control and precision for effective VMI [17, 19, 20].

Moderate correlations between VP and MC suggest that improved perceptual processing may facilitate motor coordination, while weak-to-moderate associations between VP and VMI indicate that perceptual abilities alone are insufficient for optimal VMI performance [16, 17, 20]. These findings are consistent with studies showing that VMI reflects the integrated functioning of perceptual and motor systems, and deficits in either domain can impair overall function. Children with ASD often demonstrate difficulties in visual perception during dynamic tasks and imitation, which in turn affect motor planning and execution [12, 13, 20, 27]. Visuospatial processing contributes to spatial orientation, movement planning, and interaction with objects, thereby influencing MC and VMI outcomes [16, 29, 30]. The present findings empirically reinforce these relationships, emphasizing the interconnected nature of perceptual and motor domains in ASD.

### Limitations and Recommendations

The relatively small sample size and restriction to middle childhood limit generalizability. Additionally, the cross-sectional design prevents conclusions regarding developmental causality. Future research should employ larger, longitudinal samples and incorporate neurophysiological measures to elucidate mechanisms underlying VMI in ASD. Clinically, intervention programs should prioritize integrated motor and visual–motor training to optimize functional outcomes [16, 20, 27].

### CONCLUSION

This study provides evidence that motor coordination and visual–motor integration demonstrate significant age-related improvement during childhood in children with ASD, whereas visual perception remains relatively stable. The strong association between MC and VMI underscores the critical role of fine motor control in supporting effective visual–motor performance.

Findings contribute to understanding developmental patterns in perceptual–motor functioning among children with ASD and highlight the importance of early, integrated occupational therapy interventions that target motor coordination and VMI rather than focusing solely on visual perceptual skills. Such evidence-based approaches have the potential to enhance academic

performance, functional independence, and participation in everyday activities for children with ASD [16, 17, 20, 27, 30].

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