

# Original Article

## Development of a Battery to Assess Perceptual-Motor, Cognition, Language, and Scholastic Skills among Bengali Children with Neuro Developmental Disorders

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### ABSTRACT

**Background:** School failure or poor academic performance is often found in neurodevelopmental disorders (NDD); however, there is a dearth of a comprehensive assessment tool to evaluate various underlying deficits, including perceptual-motor, cognitive, language, and scholastic skills of those who have NDD. The study aimed to develop a test to fill-up this gap. **Materials and Methods:** The study followed three phases: the construction of an assessment battery in both Bengali and English languages, separately, incorporating tasks on perceptual-motor, cognitive, language, and scholastic skills; doing a pilot study, and finally, standardization. Standardization was done on 91 normal children (NC) aged 4.5 to 9.5 years, from four districts of West Bengal. The test was applied to 57 children with poor school performance across various NDD, including specific learning disorder, autism spectrum disorder, attention deficit/hyperactivity disorder, and communication disorder. Binet Kamat Test (BKT) of intelligence, National Institute of Mental Health and Neuro-Sciences (NIMHANS) Index for specific learning disability (SLD), Childhood Autism Rating Scale (CARS), Conner's Abbreviated Rating Scale- Parent Report, Linguistic Profile Test, and Test of Pragmatic Language were used as screening tools to identify children with various NDD. The psychometric properties of the tool were assessed. **Results:** The factor analysis suggested four-factor solution named scholastic-cognitive-motor, attention, auditory-verbal, and perceptual skill. The internal consistency of the test was found to be higher (Cronbach's  $\alpha > 0.70$  for most tests), indicating high reliability. Discriminant validity revealed significant score differences between NC and children with NDD ( $P < .01$ ), suggesting that the new tool can differentiate children with NDD from healthy NC. **Conclusion:** The results favor the new tool as a psychometrically strong

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tool to assess the scholastic backwardness of children with NDD. It may be further used to create specific profiles for different categories of NDD.

**Key words:** *Assessment battery, cognition, language, perceptual-motor skills, scholastic backwardness*

**Key messages:**

- *There is a dearth of a comprehensive battery that identifies scholastic backwardness from the information-processing perspective of children having NDD.*
- *A new, culturally sound battery is introduced with acceptable reliability and validity, which may be of help to identify the nature of specific deficits in NDD and to plan intervention.*

A congenial and stimulating environment, age-appropriate emotional wellbeing, and sensory, motor, cognitive, and linguistic skills are primary prerequisites for a child to acquire literacy and successfully finish schooling. In India, children dropping out of school is a frequent phenomenon, of which some are because of inadequate ability to acquire scholastic skills (e.g., reading, comprehension (COM), written expression, computation, etc.). Assessment or intervention for these school dropouts is still an uphill task and it is furthermore difficult for the students with neurodevelopmental disorders (NDD). Research has shown that a complex network of neural pathways is responsible for learning.<sup>[1,2]</sup> Even a minimal disruption in this mechanism shows up as an impairment, disability, disorder, or difficulty in a given function. The fifth edition of Diagnostic and Statistical Manual of Mental Disorders (DSM-5)<sup>[3]</sup> categorizes such deficits among young children under NDD, like, autism spectrum disorder (ASD), attention deficit/hyperactivity disorder (ADHD), communication disorder (CD), specific learning disorder (SLD), and intellectual developmental disorder. These conditions often lead to scholastic difficulties, emotional problems, school truancy, and low self-esteem.<sup>[4]</sup>

Today, the revised Rights of Persons with Disabilities (PWD) Act, 2016<sup>[5]</sup> is a step to identify and help such children to cope in life; however, unavailability of one standardized tool suitable across the different mediums of school instruction is a major hurdle in evaluating the NDD children with scholastic difficulties. Unfortunately, there is a dearth of a comprehensive psychological assessment tool that may be used across most NDD without intellectual disability to identify kinds of underlying deficits in various domains, including academics. Clinicians choose tests from existing test batteries and translate test items to their regional language. As a result, it might be difficult to get a uniform report that would help decide a management plan. All these necessitate the development of a comprehensive test battery comprising of various

faculties, including perceptual, cognitive, language, and scholastic skills.

Difficulties in scholastic skills (like reading, COM, expression, writing, spelling [SPL], and mathematics) associated with various NDDs can be the result of a deficit in one or more processes of learning.<sup>[6]</sup> The acquisition of these skills requires the brain to process multimodal information in different parts of the brain that constitute the information processing model for mental development.<sup>[7]</sup> This theory attempts to describe how sensory input is perceived, transformed, reduced, elaborated, stored, retrieved, and used by the human mind. It includes attention mechanisms for bringing in information, working memory for actively manipulating information, and long-term memory for passively holding information so that it can be used in the future.<sup>[8]</sup>

Identifying the deficits in mechanisms underlying information processing can help in better intervention planning to improve performance and increase self-esteem.<sup>[9]</sup> Most of these findings have been established in western countries on tools standardized on their populations. Some of the tests that are developed in India to tap down many of the above-mentioned functions, like the National Institute of Mental Health and Neuro-Sciences (NIMHANS) Index for SLD, lack originality and are specially designed for a specific NDD group. Moreover, language skill is one important domain in scholastic skills, and it is absent from this tool. Keeping this in mind and considering the heterogeneity of NDD, the current study was conceptualized with the aim to develop an assessment tool to cater to difficulties in learning the scholastic skills among Bengali children with NDD attending Bengali or English medium schools. In addition, it would be more beneficial with respect to interventions if detection of the problems were done at the preprimary level, which is often not covered in most of the existing tests like the diagnostic test of learning disability (DTLD).

## MATERIALS AND METHODS

### Study design

This study involved three phases, including test construction, pilot study, and standardization. The study was carried out over a period of 5 years from 2012 to 2017 (Phase I- 2 years; Phase II- 1 year, and Phase III- 2 years). The institutional ethics committee approved the study.

### Phase I: Description and preparation of the battery

The objective of this phase was to develop a comprehensive test battery to assess scholastic difficulties in terms of information processing deficits among children with NDD. Reading skill deficits may result from deficits in speech perception<sup>[10]</sup> or basic auditory processing,<sup>[11]</sup> poor ocular motor control necessary for spatial coding,<sup>[12]</sup> or problems in visual attention (VUAT).<sup>[13]</sup> Likewise, the written expression can be affected by cognition, along with problems in language, reading, SPL, or visuomotor skills. Underlying shortcomings that interfere with handwriting performances are poor motor skills, difficult temperament, faulty visual perception of letters and words, and difficulty in retaining visual impressions.<sup>[14]</sup> Similarly, mathematical learning incorporates language, conceptual, visual-spatial, and memory abilities. Assessing visual organization and reasoning ability was also necessary for students with learning disorders in mathematics.<sup>[15]</sup> Keeping these foundations in mind, the domains were planned and the authors prepared the items. The authors also reviewed available tools to formulate some of the tasks for perceptual-motor, cognitive, and language domains. The scholastic skills were selected in terms of common skills that are prerequisites to pursue schooling and the skills included in the curriculum of government-run schools in West Bengal. Each domain has subdomains, as given in Table 1. The application of the tool was initiated with 4 major domains and 32 specific subdomains that identify different dominant functions from the embedded composite. Details of these functions are mentioned in Table 1.

The items of each subdomain were revised to determine the index of discrimination by gradually increasing the difficulty level of the items. The tasks were open-ended, closed-ended, or semi-open ended. The items developed were sent to experts (child psychiatrists, clinical psychologists, speech-language pathologists, special educators, and primary school teachers) to get their ratings with respect to relevance, appropriateness, and difficulty level of the task for the specific domain. Their suggestions were incorporated and the necessary changes made in the items. Reading COM, written expression, and handwriting tasks were dropped

as the experts observed a lack of objectivity in the scoring (these three domains have been worked upon in a subsequent study).

The tool was prepared in the form of three booklets:

1. Manual- with instructions on how to execute the tests, answer keys, scoring patterns, identifiers, and codes
2. Stimulus booklet- with all the visual stimuli
3. Response booklet- with all sociodemographics, closed-ended questions, and worksheets.

### Phase II: Pilot/Try out phase and establishment of initial validity

The researchers selected four English medium schools where sensitization programs on scholastic difficulties were conducted. Informed consent was taken from the parents of children from classes I to V with the assent of the children to participate in the study. The children with mother tongue as Bengali only were considered. In the pilot phase, five students (both boys and girls), with appreciable academic performance in the school, were selected from each class. Thus, 25 students were administered the assessment battery in a structured environment in 2 to 3 sessions within a span of 2 weeks. Trained clinical psychologists under the supervision of the researchers carried out the assessment. Based on the results of the pilot phase, the object trail task was removed, as it was too easy for almost all children. The difficulty level of some of the tasks was increased. The final tool was then given to their experts including a neuropsychologist, clinical psychologist, and a special educator. The face validity of the tool was found to be adequate.

### Phase III: Main phase and standardization

This phase consisted of two parts. In the first part, the goal was to assess the internal consistency of the subscales. Forty school-going children, as per the inclusion and exclusion criteria mentioned below, were assessed on the newly developed tool. Subtests were introduced in the order as it appears in Table 2. An item-total correlation was also calculated to assess the power of each item in the subdomain, and the less powered (Cronbach  $\alpha < 0.70$ )<sup>[18]</sup> items were removed.

Details of the second part are mentioned below.

### Study population and sample

School-going children from urban and semi-urban areas of West Bengal state covering four districts (Howrah, Kolkata, North, and South 24 Parganas) were considered for this phase. Two English medium schools from each district were approached where the authors had done sensitization seminars for teachers and parents before. Parental consent and assent of children

**Table 1: Domains and subdomains of assessment battery and their functional implications**

Domains	Subdomains	Functions <sup>[16]</sup>
Perceptual Motor		
1.	LM*	Gross visuomotor control, monitoring, and learning
2.	SM*	Fine visuomotor control, monitoring, and learning
3.	Visual perceptual and motor integration	Motor control, balancing and response inhibition
4.	Position in space	Orientation to visual space (i.e., perceptual orientation), scanning, visual discrimination, as well as visual identification
5.	Spatial relations	Visuo-motor coordination, visual scanning, and visual serial processing
Cognitive		
1.	Analogy and similarities	Attributional and relational similarity thus measuring verbal concept attainment
2.	VR*	Perceptual reasoning through visual processing of information, identify visual semantic association and concept formation, as well as problem-solving analysis and inferences
3.	Categorization	Relationship between subjects of knowledge. It measures both discrimination and commonality between objects and is associated with conceptual coherence
4.	Object trail	Focused attention
5.	Auditory verbal memory*	A measure of general verbal learning ability. It also assesses AUA and ability to encode, combine store and recover verbal information in different stages of immediate memory
6.	Visual working memory	Ability to work with visual stimuli within short-term memory. It is also a measure of visual mapping
7.	Visual span	VUAT
8.	VSQM*	Recognition of sequence, discrimination of the same, and reproduction of sequence
9.	Visual implicit memory	Perceptual learning task assesses perceptual closure and has been associated with concept formation and perceptual recognition of object
10.	Auditory visual integration	Combining auditory and visual information
11.	AUA*	Sustained attention and discrimination in the auditory modality, as well as assess response disinhibition
12.	VUAT*	Sustained attention and discrimination in the visual modality, as well as assess response disinhibition
Language		
1.	Phonological awareness	Segmenting and identifying the smallest mental unit of the sound in different positions-initial, medial, and ending. It also involves phonological awareness
2.	ACOM*	Assesses receptive knowledge and whether the child is able to follow multistep instruction
3.	ARP*	A task of auditory recognition or COM that involves phonological awareness and syntactical knowledge. It also assesses oro-motor control (i.e., decoding and encoding of an utterance)
4.	PRG*	Measures structural linguistic knowledge and preexisting knowledge. This involves the linguistic encode or meaning of an utterance. It also assesses associative and inferential thinking
5.	Syntax	Involves grammatical and logical order that connects the linguistic meaning with linguistic form
6.	Vocabulary	Assesses word meaning
Scholastic Skills <sup>[17]</sup>		
1.	NA*	Involves number recognition (symbol mapping), one to one correspondence, counting (boot up), manipulation of numbers, verbal motor match while counting, linear number placement, symbolic, and nonsymbolic matching between symbol and nonsymbol. These involve decomposing, rearranging, and recomposing of numbers
2.	LTR*	Identification of letters after getting auditory information

*Contd...*

**Table 1: Contd...**

Domains	Subdomains	Functions <sup>[17]</sup>
3.	WR*	A task of word recognition skill to assess orthographic adequacy. This also measures memory-based phonological decoding skill and involves simultaneous processing of information
4.	Pseudo WR	Assesses phonological processing awareness or orthographic phonological skill and the ability of decoding script with its conventional sound system
5.	Reading COM*	Assesses both sustained attention and simultaneous processing of words, sentences, and context
6.	QT*	Assesses mathematical awareness and quantifying skills. It involves nonsymbolic and symbolic—numerical capacity of processing, discrimination of numerical quantities, and problem-solving (transcoding)
7.	SPL*	The measure of phonemic awareness and memory. It assesses auditory linguistic retrieval efficiency
8.	Written expression	Organizing thoughts and expressing them in the written mode
9.	Handwriting	Fine-motor coordination

\*These tests were finally included in the battery. LM – Large muscle, SM – Small muscle, VR – Visual reasoning, VSQM – Visual sequential memory, AUA – Auditory attention, VUAT – Visual attention, ACOM – Auditory comprehension, ARP – Auditory repetition, PRG – Pragmatics, NA – Numerical ability, LTR – Letter recognition, WR – Word reading, COM – Comprehension, QT – Quantitative thinking, SPL – Spelling

**Table 2: Internal consistency of the items within a domain**

Sr. No.	Domains	No. of Items	Total Cronbach's $\alpha$
1	LM	18	0.94
2	SM	7	0.58
3	Spatial relation	9	0.86
4	Visuomotor	9	0.81
5	VSQM	5	0.81
6	Categorization	8	0.82
7	Visual working memory	12	0.75
8	Implicit memory	6	0.89
9	VR	10	0.74
10	Auditory visual integration	4	0.88
11	Analogy and similarities	7	0.82
12	Position in space	17	0.89
13	Visual span	5	0.43
14	NA	31	0.97
15	SPL	28	0.97
16	Letter reading	18	0.99
17	QT	29	0.86
18	WR	42	0.99
19	Pseudo WR	29	0.98
20	Reading COM	24	0.98
21	Phonological awareness	34	0.97
22	ARP	8	0.94
23	Syntax	12	0.80
24	Pragmatix	48	0.88
25	ACOM	3	0.86
26	Vocabulary	28	0.97

LM – Large muscle, SM – Small muscle, VSQM – Visual sequential memory, VR – Visual reasoning, NA – Numerical ability, SPL – Spelling, QT – Quantitative thinking, WR – Word reading, COM – Comprehension, ARP – Auditory repetition, ACOM – Auditory comprehension

could be obtained from 345 students, and they were rated by the respective teachers on Behavioral Checklist for Screening the Learning Disabled (BCSLD) to rule out any form of learning problems. Fifty-two students

were not considered as normal control because of elevated score in BCSLD. Out of 293 children without significant learning problems, 100 children ( $N_1 = 100$ ) were randomly selected for further assessment using the newly developed battery.

Sixty children ( $N_2 = 60$ ) with NDD were selected from child development clinics of Kolkata, where representative population from these four districts could be found. Selected categories of NDD were children with Attention Deficit/Hyperactivity Disorder (ADHD), Specific Learning Disorder (SLD), Language Disorder under CD (LD), and Autism Spectrum Disorder (ASD).

#### *Inclusion criteria*

Aged 4.5 to 9.5 years, both genders, at least 2 years of schooling, and understands and speaks Bengali and English

#### *Exclusion criteria*

For children with NDD: a history of seizure disorder, any sensory impairment, first-generation learner, started schooling after 3 years 6 months of age, and intelligence quotient (IQ) < 90.

For normal children (NC): IQ < 90, in addition to the above conditions.

#### **Materials**

- Behavioral checklist for screening the learning disabled (BCSLD)<sup>[19]</sup>
- Binet Kamat test (BKT) of intelligence<sup>[20]</sup>
- NIMHANS-SLD<sup>[21]</sup>
- The Childhood Autism Rating Scale- 2<sup>nd</sup> Edition (CARS-2)<sup>[22]</sup>
- Conner's 10 items Abbreviated Rating Scale- Parent Rating (CARS-PR)<sup>[23]</sup>

- Linguistic Profile Test (LPT)<sup>[24]</sup>
- Test of Pragmatic Language 2<sup>nd</sup> Edition (TOPL-2).<sup>[25]</sup>

**Data management**

The 60 students with poor academic performance were assessed with BKT, NIMHANS-SLD, CARS-PR, CARS-2, LPT, and TOPL-2 to identify causes of poor scholastic performance and comorbid factors. Of the 100 NC, the total assessment battery could not be completed on nine children. For 60 NDD children, three had to be dropped for having comorbid conditions. Trained clinical psychologists and special educators who were provided special training on assessment assessed the 148 children in various categories on our modified assessment battery. Assessment of each child was done in a structured setting in two to three sessions within a span of 2 weeks.

A schematic diagram of various phases is given in Figure 1.

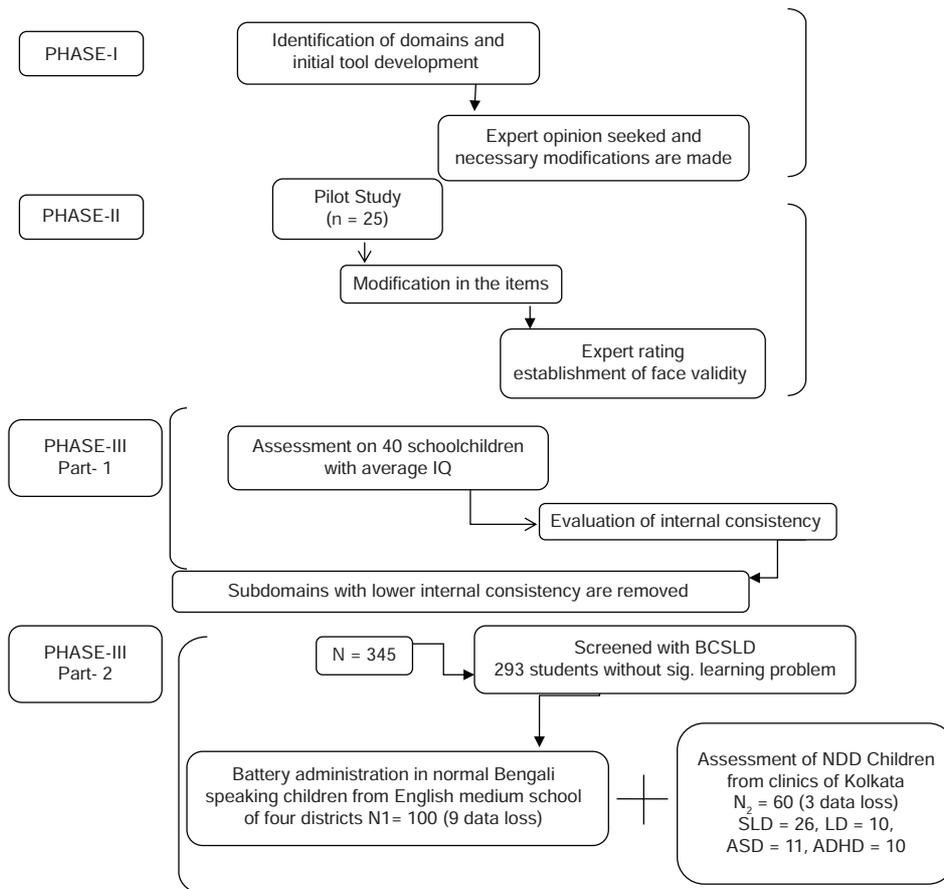
**Data analysis**

Statistical calculation was done in the Statistical Package for the Social Sciences (SPSS) software, version 15.<sup>[26]</sup>

Internal consistency was assessed by the item-total correlation of each subdomain. To assess the construct validity, exploratory factor analysis (EFA) through principal component factor analysis (PCFA) was run for 148 children ( $N_1 + N_2$ ) to identify factor solutions. Domains with low and ambiguous factor loading were excluded to get the final battery. Mean and the standard deviation (SD) was computed for every subdomain. To assess if the normal children had a normal distribution, the Shapiro–Wilk test was run. The student’s *t*-test was used to compare the performance of NC and children with NDD across the subdomains.

**RESULTS**

Table 3 shows the age and gender-wise distribution of NC and children with scholastic problems in different NDD. The NC was divided into five age groups. The lowest group was aged 4.5 to 5.5 years, while age above 8.5 years until 9.5 years was considered as the upper age group. Age and gender-wise distributions were almost equal in the NC group except for the uppermost age group where data were discarded because of missing data. In the NDD



**Figure 1:** Schematic diagram of the various phases of the tool development. BCSLD = Behavioural checklist for screening the learning disabled, NDD = Neurodevelopmental disorder, SLD = Specific learning disorder, LD = Language disorder; ASD = Autism, ADHD = Attention deficit hyperactive disorder

group, the uppermost age group was underrepresented. Table 3 shows that the gender distribution of NDD children was overrepresented by males (75%).

Table 2 shows the internal consistency of a particular subtest, which is represented as the Cronbach  $\alpha$  score. Internal consistency for most of the subdomains was higher than 0.70. The visual span task was found to have poor internal consistency and hence, it was deleted. The small muscle (SM) task had a moderate level of internal consistency, maybe because of the discrete pattern of the items. However, it was retained, as it might be a developmentally appropriate task. For some of the subdomains, it could not be calculated (e.g., auditory verbal learning) as the nature of the task was not with an increasing difficulty level.

As Kaiser–Meyer–Olkin (KMO) measure for sampling adequacy was 0.886 for a sample of 148 and Bartlett’s test of sphericity was significant at  $P < .001$ , the sample size was adequate to run EFA.<sup>[27]</sup>

The PCFA extracted four factors [Table 4] after following all necessary steps to remove the cross

and poor loading factors. Domains that could not discriminate groups of NDD from each other were also deleted (Table not shown). Component matrix scores of 0.5 or above only were considered in the rotation matrix to identify high loading factors, as the sample size is less than 150.<sup>[27]</sup> Some of the domains, like vocabulary, could not be identified under any factor because of a low factor loading score. A total of 16 subtests yielded a 4-factor solution. The analysis revealed that a total of seven subtests were loaded on the first factor, three on the second factor, four on the third factor, and the remaining two on factor 4. This resulted in the best-defined factor structure with only two domains, SM and pragmatics (PRG) task the factor loading was below 0.60.

A descriptive level was given to each factor based on the resemblance in the subtests. It can be seen in Table 4 that the first factor is loaded with five subtests requiring scholastic abilities, one subtest of visual reasoning (VR), and one subtest of Fine-Motor Skill. This factor was renamed as scholastic-cognitive-motor skill. The second factor is loaded with three subtests requiring auditory-VUAT and sequential processing.

**Table 3: Age- and gender-wise distribution of NC and NDD**

Group (Years)	4.5–5.5	5.5–6.5	6.5–7.5	7.5–8.5	8.5–9.5	Total
NC	21 (23%) M=10, F=11	20 (22%) M=9, F=11	20 (22%) M=10, F=10	20 (22%) M=10, F=10	10 (11%) M=7, F=3	91 (M=46 [50.5%], F=45 [49.5%])
NDD	15 (26%) M=11, F=4	10 (18%) M=6, F=4	12 (21%) M=10, F=2	15 (26%) M=11, F=4	5 (9%) M=5	57 (M=43 [75.4%], F=14 [24.6%])

NC – Normal children, NDD – Neurodevelopmental disorder, M – Male, F – Female

**Table 4: Factor extraction of the subtests**

	Rotated Component Matrix <sup>a</sup>			
	Component			
	1 (Variance=45.50%)	2 (Variance=9.84%)	3 (Variance=7.42%)	4 (Variance=6.79%)
WR	0.87			
NA	0.86			
COM	0.83			
SPL	0.79			
QT	0.75			
VR	0.63			
SM	0.57			
AUATTR		0.80		
VUATTIM		-0.77		
VSQM		0.69		
ARP			0.81	
ACOM			0.67	
AVL			0.61	
PRG			0.52	
LTR				0.83
VUATTR				0.67

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. WR – Word reading, NA – Numerical ability, COM – Comprehension, SPL – Spelling, QT – Quantitative thinking, VR – Visual reasoning, SM – Small muscle, AUATTR – Auditory attention right response, VUATTIM – Visual attention time, VSQM – Visual sequential memory, ARP – Auditory repetition, ACOM – Auditory comprehension, AVL – Auditory verbal learning (all trial), PRG – Pragmatics, LTR – Letter recognition, VUATTR – Visual attention right recognition

This factor was hence renamed as Attention Skill. The Third Factor is loaded with three language tasks and one verbal learning task. Hence, this factor was renamed as Language Skill. The Fourth Factor was loaded with two subtests requiring scanning and recognition of visual letters or objects. This was renamed as Visual-Perceptual Skill.

Other psychometric properties of the tool were also established. For the assessment of reliability, internal consistency within as well as between the factors was calculated through the correlation matrix (Table not given), and it revealed that the domains within the factors were highly correlated. The correlation between the factors was also significant, suggesting that the factors are inter-related and that a deficit in one area may influence the function in other areas too.

For the establishment of Discriminant Validity, NC and NDD children were compared on all four factors [Table 5]. Both the groups differed significantly in all the factors, including subdomains, except in VSQM. Hence, it could be said that the test is able to discriminate NC from the NDD group successfully. A similar assessment was also done across five age groups and between various NDD groups. Part of this assessment is given in Table 6.

## DISCUSSION

Academic underachievement is a difficult and common experience of most children with childhood disorders. The cause and nature of the difficulties are different for every child and every disorder. Because brain dysfunction in childhood has implications on multiple regions of the brain, detecting co-morbidities is a very significant necessity for planning intervention.<sup>[28]</sup> It is well established that neurodevelopmental dysfunction that reflects disruptions of the neuroanatomic structure may affect psychophysiological function too, making the child at-risk for cognitive, developmental, emotional, behavioral, social, and adaptive challenges including academic functions.<sup>[29]</sup> Studies have identified core neurodevelopmental processes that are critical for academic success and these include Sensory-Motor, Language, Visual-Perceptual, and Cognitive development.<sup>[29]</sup> The current study incorporated all these developmental functions in the new tool [Table 1] and also included domains related to academic skills. The conceptualization of the tool was comprehensive from the neurodevelopmental perspective, and its need in the Indian context cannot be denied as there is a lack of a standardized comprehensive assessment tool, especially in the Bengali population.

**Table 5: Discrimination of domain scores in two groups NC and NDD**

Subtests	Group	Group Statistics			
		N	Mean	SD	t-score
Factor 1 (Scholastic–Cognitive–Motor Skill)					
WR	NC	91	28.62	13.75	5.53*
	NDD	57	15.63	14.12	
NA	NC	91	26.59	7.79	3.43*
	NDD	57	22.26	7.10	
COM	NC	91	48.48	38.52	4.24*
	NDD	57	24.39	23.83	
SPL	NC	91	19.36	7.64	5.35*
	NDD	57	12.46	7.64	
QT	NC	91	22.67	6.33	5.95*
	NDD	57	15.40	8.48	
VR	NC	91	6.25	2.60	2.75*
	NDD	57	5.14	2.01	
SM	NC	91	21.04	2.67	2.95*
	NDD	57	19.58	3.34	
Factor 2 (Attention Skill)					
AUATTR	NC	91	26.33	3.15	4.53*
	NDD	57	22.16	7.85	
VUATTIM	NC	91	39.29	12.28	-3.26*
	NDD	57	52.61	35.79	
VSQM	NC	91	16.71	6.47	1.01**
	NDD	57	15.51	7.87	
Factor 3 (Auditory–Verbal Skill)					
ARP	NC	91	14.33	2.48	4.14*
	NDD	57	11.79	4.95	
ACOM	NC	91	13.76	2.95	7.60*
	NDD	57	9.65	3.57	
AVL	NC	91	39.58	9.51	6.61*
	NDD	57	28.05	11.54	
PRG	NC	91	14.93	5.40	11.43*
	NDD	57	5.72	3.54	
Factor 4 (Visual–Perceptual Skill)					
LTR	NC	91	70.96	0.21	6.49*
	NDD	55	69.53	2.09	
VUATTR	NC	91	28.93	1.87	5.43*
	NDD	57	26.09	4.42	

\*Significant at  $P < 0.01$ . \*\* Not Significant. NC – Normal children, NDD – Neurodevelopmental disorder, SD – Standard deviation, WR – Word reading, NA – Numerical ability, COM – Comprehension, SPL – Spelling, QT – Quantitative thinking, VR – Visual reasoning, SM – Small muscle, AUATTR – Auditory attention right response, VUATTIM – Visual attention-time, VSQM – Visual sequential memory, ARP – Auditory repetition, ACOM – Auditory comprehension, AVL – Auditory verbal learning (All trials), PRG – Pragmatics, LTR – Letter recognition, VUATTR – Visual attention right recognition

In this context, it might be helpful to discuss the reasons for the selection of perceptual-motor as well as cognitive tasks to assess children with neurodevelopmental disorders. Motor coordination problems are common in children with ADHD<sup>[30]</sup> with associated cerebellar dysfunction. Studies have reported a smaller cerebellum size in ADHD children.<sup>[31,32]</sup> Movement deficits are also evident in SLD,<sup>[33]</sup> LD<sup>[34]</sup> and autism,<sup>[35]</sup> though the assessment and research focus is not primarily on this domain.

**Table 6: Comparison between various NDD groups and NC**

Subtests	Group	N	Mean Rank	Chi-Square Value
Factor-1				
WR	SLD	28	48.93	34.96**
	LD	10	36.60	
	ADHD	10	50.65	
	ASD	9	59.67	
	NC	91	90.62	
NA	SLD		64.16	11.62*
	LD		61.70	
	ADHD		59.80	
	ASD		46.44	
	NC		83.48	
COM	SLD		60.09	14.42**
	LD		49.00	
	ADHD		54.95	
	ASD		65.39	
	NC		84.79	
SPL	SLD		59.89	31.18**
	LD		23.80	
	ADHD		60.25	
	ASD		50.22	
	NC		88.53	
QT	SLD		63.79	32.26**
	LD		23.45	
	ADHD		53.50	
	ASD		45.67	
	NC		88.57	
VR	SLD		62.16	14.02**
	LD		43.20	
	ADHD		54.80	
	ASD		81.39	
	NC		83.22	
SM	SLD		75.38	16.60**
	LD		32.70	
	ADHD		52.25	
	ASD		61.33	
	NC		82.57	
Factor 2				
AUATTR	SLD		64.71	21.61**
	LD		36.20	
	ADHD		42.05	
	ASD		71.11	
	NC		85.62	
VUATTIM	SLD		74.66	7.43
	LD		106.55	
	ADHD		78.15	
	ASD		84.72	
	NC		69.52	
VSQM	SLD		74.59	7.09
	LD		50.30	
	ADHD		59.70	
	ASD		97.00	
	NC		76.53	
Factor 3				
ARP	SLD		71.62	18.69**
	LD		25.60	
	ADHD		75.85	

Contd...

**Table 6: Contd...**

Subtests	Group	N	Mean Rank	Chi-Square Value
ACOM	ASD		69.06	58.54**
	NC		81.15	
	SLD		40.80	
	LD		27.15	
	ADHD		52.35	
AVL	ASD		46.06	38.52**
	NC		95.32	
	SLD		49.93	
	LD		21.60	
	ADHD		63.75	
PRG	ASD		61.11	76.98**
	NC		90.38	
	SLD		44.66	
	LD		20.25	
	ADHD		31.60	
Factor 4				
LTR	SLD		55.75	67.12**
	LD		51.44	
	ADHD		23.80	
	ASD		40.33	
	NC		89.64	
VUATTR	SLD		70.54	24.00**
	LD		38.55	
	ADHD		43.00	
	ASD		55.67	
	NC		84.99	

\*Significant at  $P < 0.05$ . \*\*Significant at  $P < 0.01$ . WR – Word reading, SLD – Specific learning disorder, LD – Language disorder, ASD – Autism, ADHD – Attention deficit hyperactive disorder; NC – Normal children, NA – Numerical ability, SPL – Spelling, QT – Quantitative thinking, VR – Visual reasoning, SM – Small muscle, AUATTR – Auditory attention right response, VUATTIM – Visual attention-time, VSQM – Visual sequential memory, ARP – Auditory repetition, ACOM – Auditory comprehension

The initial factor analysis classified the tool into four factors, namely, scholastic–cognitive–motor skill, attention skill, language or auditory–verbal skill and visual–perceptual skill. The division of four-factor goes pretty well with the understanding of the neurodevelopmental process from the information processing perspective.<sup>[36-38]</sup> The most popularly used NIMHANS Index for the SLD tool has also incorporated similar domains except the Language domain. The emergence of auditory–verbal as a separate factor shows it is important for assessing NDD and in planning intervention.

Verbal reasoning, a task related to the executive function of cognitive development<sup>[39]</sup> been better understood with tasks related to attentional skill in the second factor. However, most of the scholastic skills, including reading COM, SPL, numerical ability (NA), etc., as reported by some recent researches are highly predicted by executive function tasks,<sup>[40,41]</sup> especially

reasoning and critical analysis.<sup>[42]</sup> Other authors have reported that fine motor skill is one of the key factors for academic readiness in children<sup>[43,44]</sup> and this skill along with executive function skills are the strongest predictors of academic achievement.<sup>[45]</sup> This might be the reason that VR and SM tasks were identified with Factor 1. However, during the assessment, it might be beneficial to interpret the findings separately for scholastic, cognitive/executive function and fine-motor tasks for a better understanding of the underlying process of the academic deficit.

Factor 2 rightly identified the task related to attentional processes and included tasks on sustained visual attention and sustained auditory attention (AUA). Both of these tasks also assess discrimination and sensory disinhibition. This factor has also identified VSQM that assesses recognition of sequence and reproduction of the same. Though this is part of visual short-term memory, this is also considered as a measure of sequential attention, which is highly related to the reading and SPL ability of an individual.<sup>[46]</sup>

The third factor identified the tasks on auditory-verbal skills, though it has excluded some of the core tasks related to auditory-verbal skills, such as syntax and phonological awareness. As tasks such as auditory comprehension (ACOM) and repetition involve both syntactic knowledge and phonological awareness skill, they might be considered as multifaceted tasks that engage all aspects of language or auditory-verbal processing.<sup>[47]</sup> PRG skill is necessary for conversation and social communication. In many neurodevelopmental conditions, including communication disorder, ASD and language impairment, the role of PRG skill deficit is well established.<sup>[48]</sup> Its implication in other NDD like ADHD is also documented.<sup>[49]</sup> The Auditory Verbal Learning Task, a primary measure of the verbal learning potential of an individual,<sup>[50]</sup> was identified in this factor as it involves auditory-verbal processes of learning. Total Learning score was only considered as it is found to be developmentally sensitive.<sup>[51]</sup>

The fourth factor, renamed as perceptual skill, includes two specific tasks of letter recognition (LTR) and identification of the appropriate visual stimuli. Both the tasks demand visual searching from the crowding of letters or pictorial stimuli. Both tasks involve perceptual learning, which is crucial for proper reading.<sup>[52]</sup>

Psychometric analysis suggests that the internal consistency of the tool is high. As most of the tasks were developmentally oriented, making two halves of every subdomain consisting of similar tasks was not possible; thus, split-half reliability could not be tested. The establishment of construct validity and discriminant

validity are the strengths of this tool. Despite having a smaller sample size, this tool has other advantages; authors have tried their best to keep it culturally appropriate by developing original items. When we conceptualized the tool, it appeared as a lengthy one, but after PCFA, it has become almost half in length, and that would considerably reduce the administration time. Moreover, the mean and SD scores of NC could be used to decide the task-wise deficit of children with NDD.

However, the tool is not out of limitations that may be taken care of during the future expansion of the tool. More samples from normal, as well as clinical populations, might be helpful to minimize the effect of sampling bias. Moreover, the establishment of test-retest reliability and concurrent validity of the tool should be incorporated and that will further strengthen the psychometric property of the battery. There is also a scope to expand the tool to get a specific profile of various NDD subgroups, which might guide us to obtain specific diagnostic indicators.

## CONCLUSION

Various NDDs follow similar cognitive processes and have high comorbidity with each other. These often create diagnostic confusion and result in a delay in proper diagnosis. At the same time, there is a lack of appropriate assessment tools for early detection of the difficulty. As a result, early intervention is mostly very difficult in a country like ours. The tool introduced in the paper is an effort to fill this gap and can be used for treatment planning, too. The current study is probably among very few endeavors to develop a test to assess scholastic backwardness across NDD in Bengali-speaking children. This tool has several advantages, including culture specificity, incorporation of most of the theoretical domains, statistical soundness, and applicability for a wide-range of NDDs at the preprimary level.

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### Conflicts of interest

There is no conflict of interest.

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