The International Journal of Indian Psychology
ISSN 2348-5396 (Online) | ISSN: 2349-3429 (Print)
Volume 9, Issue 2, April- June, 2021
DIP: 18.01.065.20210902, DOI: 10.25215.0902.065
http://www.ijip.in

Research Paper

Cognitive Deficits in School Going Children with Attention Deficit Hyperactivity Disorder

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ABSTRACT

Cognitive impairment has been found to be accompanying Attention deficit hyperactivity disorder in several studies. Cognitive abilities are key to healthy and proper functioning for any human and that's why cognitive deficits creates various types of problems in persons with cognitive impairment. The present study aimed at studying the cognitive deficits in school going children with ADHD.A cross sectional study was designed for studying the cognitive deficits in school going children with ADHD. Thirty school going children with ADHD were selected by using purposive sampling technique. DT-ADHD was used for screening purpose. All of the 30 children were assessed on Malin's Intelligence Scale for Indian Children (MISIC), Colour cancellation test, Children Colour Trail Test and Wisconsin Card Sorting Test. Statistical analysis of the findings was done by using SPSS. 20. The result showed that the school going children with ADHD performed poorly on subtests of MISIC, Wisconsin Card Sorting Test, Colour cancellation test and Children Colour Trail Test suggesting deficit in attention, concentration, in the speed of attention, in sequencing, mental flexibility, working memory, problem in shifting and maintaining set, problem in forming abstract concepts. The present study showed that the school going children with ADHD had significant cognitive deficits.

Keywords: *Attention, Concentration, Impulsivity, ADHD, Hyperactivity, Cognitive deficits, Set- shifting, Working memory*

ADHD is a disorder where the individual suffering from this disorder shows continuous pattern of inattention and/or hyperactivity-impulsivity. This pattern of inattention and/or hyperactivity-impulsivity interfere with the normal functioning of the brain and the person's adjustment to the environment. ADHD is one of the most prevalent disorder among school aged children. ADHD is a developmental and a neurological disorder which affects social, academic and the emotional life of the person suffering from ADHD. It is assumed that ADHD develops during early childhood. According to the diagnostic and statistical manual of mental disorders, 5th edition (DSM-5), attention deficit and hyperactivity disorder is defined as a neuro-developmental disorder which is characterized by impairment

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Received: April 08, 2021; Revision Received: April 22, 2021; Accepted: May 19, 2021

in the level of attention, disorganization and/or hyperactivity-impulsivity. A meta-analytic study conducted by Thomas, Sanders, Doust, Beller and Glasziou (2015) found an overall pooled estimate of world-wide prevalence of ADHD in children aged 18 and under to be 7.2%.

There have been studies which confirms the neuropsychological deficits in ADHD. There are studies which have investigated the underlying cognitive dysfunctions which affects normal functioning of the attention. ADHD has been conceptualized as an impairment of higher-order cognitive processing known as "executive function". A meta-analytic review study found that there exists a moderate level of weakness in response inhibition, working memory, impulsivity, vigilance, organization and some measure of planning (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005).

It is hypothesized that cognitive deficits, particularly impairment in focused attention and executive functions are core components of ADHD and are thought to be playing a major role in the adaptive functioning of children with ADHD (Douglas, V. 1972). Brown (2009) found that children with ADHD have difficulty in focused attention, sustained attention and shifting focus of attention which should be adequate to meet the demand of learning, work, social interaction and tasks of daily routine. It has been found that there are many cognitive problems in ADHD like problem of attention, working memory, executive functioning etc. Attention deficit is the most common problem found in children with ADHD. Children with ADHD shows primary deficit in sustained attention over time, due to which they cannot sustain attention which is very much essential for learning (Hoocks et al., 1994 and Seidel et al., 1990). Landau et al. (1992) and Barkley et al. (1992) have found problem in selective attention also in ADHD. Study done by Heaton et al. (1993) suggest problem in divided attention in ADHD. Children with ADHD consistently exhibit poorer performance on the task for executive functioning, vigilance and perceptual speed but they usually perform within normal limits on a variety or spatial measures (Barkley, 1997; Pennington & Ozonoff, 1996). Similarly, Douglas (1972) also had found that children with ADHD exhibit sub average or relatively weak performance on various tasks of vigilance, sustained attention, motoric inhibition, and executive functions.

METHODOLOGY

Aim of the study

The present study aimed at studying the cognitive deficits in school going children with ADHD.

Sample

Thirty school going children with ADHD were selected for the study by using purposive sampling technique. The age range for the children taken under the study was 8 to12 years**.** The children were selected by visiting schools of Ranchi. A short checklist was prepared for quick and initial assessment of ADHD symptoms in the starting so that teachers could be able to identify children with such problems easily and quickly and would be able to refer children with problem for the study. A detailed assessment of ADHD symptoms was evaluated by using DT-ADHD. The children who scored above the cutoff point on DT-ADHD which is essential for diagnosing the presence of ADHD and who met the inclusion and exclusion criteria were selected for the present study.

INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria

- School going children with symptoms of ADHD
- Average Intelligence
- Age between 8 to 12 years
- Children of both sex
- Children who were able to understand Hindi/English
- Children for whom parents/school's principal gave informed consent.

Exclusion criteria

- Children with any evidence of organicity and neurological condition.
- Children with any physical disability and chronic physical medical condition.
- Children with history of co-morbid psychiatric illness.
- Family history of major mental disorders.
- Recent traumatic life events.

Study design

It was a cross sectional study. Thirty school going children with symptoms of ADHD were selected by using purposive sampling technique. These children were assessed on DT-ADHD, MISIC, WCST, Children Colour Trail Test and Colour Cancellation.

Measures

Socio-demographic and personal datasheet

It is a semi structured Performa especially designed for the study. It contains several questions covering all areas of socio-demographic details like age, sex, domicile, education, etc., and question are related to illness, co-morbid psychiatric disorder, hearing and visual impairment or any severe physical illness in the near past.

A Short self-prepared checklist for ADHD

A short checklist was prepared for quick and initial assessment of ADHD symptoms in the starting so that teachers could be able to identify children with such problems easily and quickly and would be able to refer children with problem for the study.

Malin's Intelligence Scale for Indian Children

Malin's Intelligence Scale for Indian Children was developed by Arthur J. Malin in 1969. MISIC is the Indian adaptation of Weschler Intelligence Scale for Children. MISIC is used for the children from 6 years of age to 15 years of age. The test-retest reliability of MISIC is .91 for the full-scale IQ result. MISIC has concurrent and congruent validity of .63.

Diagnostic Test of Attention Deficit Hyperactivity Disorder (DT-ADHD)

DT-ADHD was developed by Singh et al. (2015). It is a rating scale particularly designed for the use of school teachers to identify their wards with attention deficit hyperactivity disorder, and Conduct Disorder. The test has 56 items describing behavior and characteristics of person with ADHD and Conduct disorder reported in the guideline of ICD-10. The behaviors are rated using a 5-point scale based on the severity of the child's problem, and it ranges from a score of 0 to 4. The possible total score ranges from 0 to 224. The assessment could be completed within 10 to 15 minutes by teachers, parents and caregivers, who have a clear knowledge about the child's behavior. The DT-ADHD consists of four subtests based on the core symptoms of ADHD and conduct disorder. The first three subtests namely Inattention,

Hyperactivity and Impulsivity comprised of item 1 through 36. Inattention measures child's problem of focusing and playing attention to the important feature of a task, and the items comprised of 1 through 12. Hyperactivity measures excessive motor activity and is comprised of items 13 through 24. Impulsivity measures the hasty action that occurs in the moment without forethought and that have high potential for harm to the individual and it contains the items of 25 through 36. The fourth subset is conduct disorder and which measures repeated acts of aggression that may cause physical harm to themselves and others, frequently violating the societal norms and rights of the others. There are 20 items in this subtest and comprised of 37 through 56. Scores are computed separately for each subtest and a total score is obtained for first three subtests and the last subtest separately. The inter-correlation for inattention subtest is .818, for hyperactivity up to .838, for impulsivity up to .797 and for conduct disorder up to .801. It shows good internal consistency of the test. Test -retest reliability for the DT-ADHD for the subtest of inattention is .929, for hyperactivity .925, for impulsivity .972 and for conduct disorder .945. It shows good test- retest reliability of the test. The face and content validity have been established for this test by taking expert opinion. Cross validity has been found to be. 749.It shows good cross validity.

Colour Cancellation Test

Colour cancellation test was developed by Kapur (1974). Colour Cancellation Test is used to measure sustained attention, visual screening, activation and inhibition of rapid response. The material required is a colour cancellation sheet, pencil and stop watch. The subject is given a cancellation sheet containing 150 circles in five different colour and the subject is instructed to cancel only red and yellow circles as fast as possible. Time taken to complete the test is recorded and error of omission and commission are noted. The norms available in the NIMHANS Neuropsychological Battery for Children was used for the interpretation purpose.

Children Colour Trail Test.

Colour trail test is used to assess focused attention as well as mental conceptual tracking and cognitive flexibility. It was developed by D'Elia, Satz, Uchiyama and White (1996). It requires Colour Trail Sheet A and B and a stopwatch. It has two parts, part A circle numbered from 1 to 25 in two colours i.e., pink and yellow. The subject is required to connect the number serially from 1 to 25 twice, one in pink and other in yellow. The subject is required to connect from 1 to 25 but altering between pink and yellow circle and disregarding the number in circles of the alternate colours. Time taken in seconds and the error committed constitutes the raw scores. The reliability of CCTT1 and CCTT2 time raw score of various factors are .81., - 11, and CCTT2 time raw score are .93 and .25. The norms available in the NIMHANS Neuropsychological Battery for Children was used for the interpretation purpose.

Wisconsin Card Sorting Test

WCST was developed as a measure of abstract reasoning ability and the ability to shift cognitive strategies in response to changing environmental contingencies (Berg, 1948). Later on, it became a popular and valid measure of executive function (Goldstein & Green, 1995). The test requires strategic planning, organized searching, the ability to use environmental feedback to shift cognitive set, goal-oriented behavior and ability to modulate impulsive responding. The participant is presented with stimulus card with shapes on them. The cards differ in colour of the shapes, number of the shapes, and the form of the shapes. The participant is asked to sort the cards. The participant is not told what stimulus dimension top use in order to sort these cards, but the administrator tells the participants if a particular match is correct. During test the sorting rules are changed and participant must discover the new sorting rule in to be successful. WCST consist of two versions, WCST-64 and WCST-

128. WCST has good reliability and validity and is being frequently used to assess executive functions in Indian studies. The test-retest reliability is found to be 0.90 for all variables. WCS-128 version was used for the present study. The scoring and interpretation system developed by Heaton et al. (1993) was used for the present study.

Procedure

Children with symptom of ADHD were selected by visiting schools. Initially the teachers were provided with a small checklist containing symptoms of ADHD. The purpose of the short checklist was a quick screening of such children having symptom of ADHD. Teachers were able to refer to the children having symptoms of ADHD. The children referred by the teachers, were screened for ADHD by using DT-ADHD and those who were meeting the criteria for a diagnosis of ADHD were selected for intelligence assessment as average intelligence was an inclusion criterion. MISIC was administered on the children with symptoms of ADHD and those who had average intelligence, were selected for the present study. MISIC is a popular standardized intelligence test in India. Apart from screening for the average intelligence in the present study, MISIC was used to find the pattern of cognitive performance in school going children with ADHD. Selected children were then assessed on Wisconsin card sorting test, Colour Cancellation Test and Children Colour Trail Test. Data obtained from the assessment were analyzed by using SPSS-20. Descriptive analysis was done to obtain Mean, Standard Deviation, range and frequency of variables under the study. One-sample t-test was used to compare the mean scores of sub-scales of MISIC and WCST with the normative sample scores. Since, an IQ score of 90 or above is considered to be normal, the test value for one-sample t-test was fixed to be 90 for MISIC. For WCST the value of 45 or above is considered to be average (Heaton et al, 1993). So, for WCST test value was fixed to be 45 in one-sample t-test.

RESULTS

There were 30 school going children with ADHD selected for the present study. The age range of the children was from 8 to 12 years. The table no.1 shows the descriptive information about socio-demographic characteristic of the sample for the present study.

Table no.1 showing socio-demographic details of the entire sample.

AGE	**N**	**N%**
8years	10	33.33
9 years	2	6.66
10 years	2	6.66
11 years	4	13.33
12 years	12	40
GENDER		
Male	28	93.33
Female	2	6.66
RELIGION		
Hindu	23	76.66
Muslim	6	20
Sarna	1	3.33
CLASS		
1ST	5	16.66
2ND	5	16.66
3RD	2	6.66
4TH	15	50
5TH	3	10

On the analysis of the obtained scores on the 10 sub-scales of MISIC, the lowest scores were found on the subscale of Digit span (83.43), Arithmetic (83.83), Picture completion (84.16), Coding (84.60), Maze (85.13), Similarity (85.33), Block design (85.86) and Performance IQ (88.82). Children performed at below average level on these scales. Since, score of 90 or above is considered to be normal, the test value for one sample t-test for MISIC was fixed to be 90.

When the mean values on each subscale was compared with the normative sample using One-sample t-test (Test value = 90), differences were found to be statistically significant (at 95% confidence interval) on subscale of Digit span, Arithmetic, Picture completion, Coding, Maze, Similarity, Block design and Performance IQ. This suggests deficits in areas assessed by these subscales of MISIC.

The mean difference on the subscales of Comprehension, Information, Vocabulary, Object assembly, Verbal IQ and Full-scale IQ was positive and significant which indicates that the children with ADHD performed at an equal level to the normal functioning scores in normative sample on these subscales of Comprehension, Information, Vocabulary, Object assembly, Verbal IQ and Full-scale IQ, suggesting absence of deficits in the areas assessed by these subscales. The Mean, SD of children with ADHD and result of one sample t-test on MISIC is shown in table no.2.

Table 2 showing Mean, SD, Range of children with ADHD and result of one sample t-test on MISIC

Descriptive analysis			**One sample t-test (test value=90)**		
	Range	**Mean**	**SD**	**Mean difference**	**t- value**
FSIQ	90.00-90.33	90.10	.12	.10	4.52**
VIQ	88.50-93.33	91.35	.81	1.35	9.10**
PIQ	87-91	88.82	.74	-1.18	8.76**
Inf	90-100	96.13	2.24	6.13	15.00**
comp	90-102	95.80	2.43	5.80	12.94**
Airth	79-92	83.83	2.64	-6.17	12.79**
Sim	82-92	85.33	1.97	-4.67	12.97**
Vocab	95-106	103.00	2.70	13.00	26.34**
DS	75-85	83.43	2.78	-6.57	12.90**
PC	75-90	84.16	2.52	-5.83	12.68**
BD	83-95	85.86	2.01	-4.13	11.25**
OA	96-106	103.53	2.75	13.53	26.94**
Code	82-89	84.60	1.59	-5.40	18.62**
Maze	81-91	85.13	2.08	-4.87	12.81**

***Significant at .001 level.*

Note-FSIQ-Full Scale Intelligence Quotient, **VIQ**- Verbal Intelligence Quotient, **PIQ**-Performance Intelligence Quotient, **Inf**- Information, **comp**-Comprehension, **Airth**-Airthmetic, **Sim**-Similarity, **Vocab**-Vocabulary, **DS**-Digit Span, **PC**-Picture Completion, **BD**-Block Design, **OA**-Object Assembly, **Code**-Coding, **Maze**-Maze.

The analysis of scores obtained on WCST was done by using descriptive statistics and one sample t-test. The mean scores obtained on WCST were, Total error (34.90), percent error (34.90), Perseverative responses (37.20), percent perseverative responses (36.47), perseverative errors (36.87), percent perseverative errors (37.40), Non-perseverative error

(40.50), percent Non-perseverative errors (40.73) and percent conceptual level (37.27). A classification system was developed for the interpretation of the normative T scores. This classification system says that that T- score from 45 to 54 is average range of performance on WCST (Heaton et al, 1993) Since, T score of 45 or above is considered to be normal, the test value for one sample t-test was fixed to be 45 for WCST. When the mean values on each subscale was compared with the normative sample using one-sample t-test (Test value = 45), differences were found to be statistically significant (at 95% confidence interval) on total error, percent total error, perseverative responses, percent perseverative responses, perseverative errors, percent perseverative errors and percent conceptual level which indicates that the children with ADHD performed below average on these subscales of WCST. The mean, SD, and result of one sample t test of WCST is presented in table no.3.

Table No.3 showing Mean, SD, Range of children with ADHD and one sample t test for WCST.

Descriptive analysis	**One sample t test**				
	Range	**Mean**	**SD**	**Mean difference**	**t (Test value = 45)**
Total error	26-51	34.90	6.70	-10.10	8.25**
%error	22-55	34.90	8.83	-10.10	6.26**
P- responses	26-55	37.20	8.84	-7.80	4.83**
%P- responses	20-58	36.47	9.93	-8.53	4.71**
P- error	26-65	36.87	9.60	-8.13	4.64**
% P error	25-61	37.40	10.51	-7.60	3.96**
Non- P error	20-80	40.50	11.80	-4.50	2.09
% Non- P error	20-80	40.73	13.09	-4.26	1.78
%conceptual level	28-61	37.27	8.92	-7.73	4.75**

*** significant at .001 level*

Note-% error- Percent error, **P-response**-Perseverative response, **% P-response**- Percent Perseverative response, **P error**- Perseverative error, **% P error**- Percent Perseverative error, **Non-P error**- Non-Perseverative error, **% Non-P error**- Percent Non-Perseverative error, **% conceptual level**- Percent Conceptual level responses.

Table no.4 is showing the frequency of the children on each of the dimension of WCST on the basis of performance level (from Average level to moderate-severe level of impairment).

Table no.4 showing frequency of children on dimensions of WCST on the basis of severity level.

	Average		**Below-average**		**Mild impairment**		**Mild-moderate impairment**		**Moderate impairment**		**Moderate-severe impairment.**	
	%	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**
Total error	10	3	17	5	20	6	27	8	27	8	None	None
%error	17	5	13	4	13	4	27	8	30	9	3	1
P-res	27	8	7	2	7	2	33	10	20	6	None	None
%P-res	23	7	13	4	13	4	23	7	30	9	3	1
P-error	17	5	10	3	10	3	33	10	23	7	None	None
% P-error	20	6	10	3	10	3	23	7	27	8	None	None
Non- P-error	27	8	23	7	23	7	20	6	3	1	7	2
% Non-P error	27	8	27	8	27	8	20	6	10	3	7	2
%Concept level	20	6	13	4	13	4	17	5	30	9	None	None

Note-**% error**- Percent error, **P-response**-Perseverative response, **% P-response**- Percent Perseverative response, **P error**- Perseverative error, **% P error**- Percent Perseverative error, **Non-P error**- Non-Perseverative error, **% Non-P error**- Percent Non-Perseverative error, **% conceptual level**- Percent Conceptual level responses.

The results on Colour cancellation test and Children colour trail test showed that most of the children performed poorly on measures of sustained and focused attention. It was found that 93% children on colour cancellation test scored above the cut off. On Children Colour Trail Test 97% children on Part A and 100% children on Part B scored above the cut off. The scores above the cut off on both of these tests suggests deficits. These results on these two tests show deficits in sustained attention, focused attention, accurate visual scanning and cognitive flexibility in most of the children with ADHD in the present study. Table no.5 is showing the frequency of children below and above the cut off on Colour cancellation test and Children colour trail test.

Table no.5 showing frequency of children below and above the cut off score on Colour Cancellation Test and Children Colour Trail Test

	Below Cut off		Above Cut off	
	N	**%**	**N**	**%**
Colour Cancellation Test	2	7	28	93
Children Colour Trail Test A	1	3	29	97
Children Colour Trail Test B	0	0	30	100

DISCUSSION

The aim of this study was to find out the cognitive deficits in school going children with ADHD. The results showed that children with ADHD performed poorly on the subscales of Malin's Intelligence Scale for Indian Children. The present study found that the children with ADHD performed poorly on subscales of Digit Span, Arithmetic, Picture Completion, Coding, Maze, Similarity, Block Design and on Performance Quotient and at an equal level to the normal functioning scores in normative sample on rest of the subscales of MISIC. Smitha, Dennis, Varghese, and Vinayan (2014) also has found in their study that children with ADHD performed poorly on subscales of Arithmetic, Digit span, Picture completion, Block design, and Coding. They also found that the children with ADHD performed at an equal level to the normal functioning score on the subscale of Similarity. The same has been found in the present study. Kontala and Haldar (2018) conducted a study to find out the cognitive functioning: working memory, verbal comprehension, perceptual reasoning and processing speed among ADHD and compare them with normal children. They selected 30 children diagnosed with ADHD and compared them with 30 normal children. All of the subjects were assessed on the Malin's Intelligence Scale for Indian Children (MISIC) to see the cognitive functioning of both the groups of children. The findings of this study showed that children with ADHD had poor cognitive function in comparison to normal children.

During Arithmetic sub-scale task, one needs to involve into mental manipulation, concentration, short- and long-term memory, numerical reasoning and sequencing (Weschler, 1991). During the assessment with this subscale, working memory plays an important role because one needs to listen to the orally presented information and retain the information during mental manipulation of the information. In the context of arithmetic, the working memory system is thought to be involved in the memorization of numbers during the arithmetic process, the spatial representation of multi-digit problems, and the initiating,

directing, and monitoring of procedures in complex arithmetic problems (McLean & Hitch, 1999).

Digit span test assesses working memory. Children with ADHD have deficits in working memory which makes them unable to hold and manipulate the information in order to give a good performance (Barkley, Fischer, Smallish, et al., 2006; Barkley, 1997; Barkley, 1998). Similar results were reported by Martinussen, Hayden, Hogg-Johnson, Tannock (2005) in a meta-analysis of working memory impairments in children with attention-deficit/hyperactivity disorder. Sinha, Sagar and Mehta, (2008) also reported that children with ADHD shows significant deficit in working memory.

Picture Completion Test is a measure of both visuo-conceptual ability and visual organization (Lezak, 1995). Block Design measures the ability to analyze and synthesize abstract visual stimuli and nonverbal concept formation. It involves visual perception and organization, visual-motor co-ordination, spatial visualization, learning and the ability to separate figure and ground in the visual card. Coding assesses the child's visuo-motor skills, visual scanning, cognitive flexibility and processing speed. The coding task also needs sustained attention and less distractibility to code more numbers of boxes without error to obtain a good score. The finding that children with ADHD perform poorly in Coding is consistent with several previous studies (Mayes & Calhoun 2004, 2006; Chhabildas, Pennington & Willcutt, 2001; Shanahan et al., 2001)

Mazes and Picture completion can give us a picture of perceptual reasoning. The children with ADHD performed poorly on both of this subscale in the present study suggesting deficit in the perceptual reasoning. Similar findings were reported by Kontala and Haldar (2018). Andreou, Agapitou, Karapetsas (2005) found that children with ADHD performed poorly on Similarity subscale. The present study found the similar finding.

Researchers suggest that the children with ADHD have primary deficit in the ability to sustain attention over time (Hoocks et al., 1994) along with difficulty in selective attention (Landau et al., 1992), and divided attention (Heaton et al., 1993). The findings from the MISIC, Colour Cancellation Test and Children Colour Trail Test in the present study also suggest the similar deficit of attention in the children with ADHD.

The WCST is traditionally believed to be the most sensitive test to frontal lobe pathology (Barkley, Grodzinsky & DuPaul, 1992; Drewe, 1974; Milner, 1963). There are studies which found significant deficits on WCST measures (Categories, Perseverative responses and Perseverative errors) in the group with ADHD. Children with ADHD were compared with normal controls in these studies. (Chelune et al. 1986; Shue & Douglas, 1989). The present study also has found the similar results.

Koflar et al. (2019) conducted a study to understand the heterogeneity found in all three primary executive functions in ADHD. The multiple criterion tests were used for each of the primary executive function (working memory, inhibitory control and set shifting). The result found in this study showed that 89% of children with ADHD had demonstrated objectively defined impairment on at least one executive functions (62% impaired working memory, 27% impaired inhibitory control, 38% impaired set shifting). This study also found that 54% were impaired on at least one executive function and 35% were impaired on two or all of three executive functions.

The present study has also found that the children with ADHD demonstrated impairment in working memory, set shifting, set maintenance, speed of attention, sequencing and mental flexibility.

CONCLUSION

The present study shows that the school going children with ADHD have significant deficit in attention, concentration, speed of attention, set shifting, set maintenance, mental flexibility, working memory, deficit in visuo-conceptual ability and visual organization; deficit in the ability to analyze and synthesize abstract visual stimuli and nonverbal concept formation; deficit in visuo-motor skills, visual scanning, cognitive flexibility and processing speed and deficit in perceptual reasoning.

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Acknowledgement

The author(s) appreciates all those who participated in the study and helped to facilitate the research process. This research article is associated with the Ph.D. research under progress.

Conflict of Interest

The author(s) declared no conflict of interest.

How to cite this article: Kumari R. & Jahan M. (2021). Cognitive Deficits in School Going Children with Attention Deficit Hyperactivity Disorder. *International Journal of Indian Psychology, 9*(2), 617-628. DIP:18.01.065.20210902, DOI:10.25215.0902.065