

Theory of Mind and Executive Functions in Children With Attention Deficit Hyperactivity Disorder and Specific Learning Disorder

Jeetinder Singh¹, Priti Arun² , and Manoj Kumar Bajaj² 

ABSTRACT

Background: Children with attention deficit hyperactivity disorder (ADHD) and specific learning disorder (SLD) generally have difficulties in social cognition and display impairments involving emotion and face and prosody perception and reduced empathy, indicating theory of mind (ToM) impairment. The objective of this work was to assess and compare the executive functions and ToM in children with ADHD and SLD.

Methods: Twenty children diagnosed with ADHD, 20 children diagnosed with SLD, and 20 normal healthy children in the age group of 7 to 15 years, IQ between 90 and 110 (average intelligence) of any gender, were recruited. All participants were assessed using neuropsychological tests of executive functions and ToM.

Results: Significant differences were found on early ToM, basic ToM, advanced ToM, and mean scores on ToM inventory between ADHD and control groups ($P \leq 0.001$). Similarly, significant differences were found between ADHD and SLD groups on early, basic, advanced, and mean ToM inventory scores ($P < 0.001$).

No significant differences were found between the control and SLD groups on ToM measures. Further, in the ToM task battery, on task D and task G, significant differences were found between the SLD and control groups at $P = 0.04$ and $P = 0.03$ respectively. Differences between ADHD and control groups were also statistically significant on task D and task G at $P < 0.001$ and $P = 0.033$. Executive functions in the form of set-shifting and response inhibition were significantly poor in the ADHD group and SLD group at $P < 0.001$ and $P < 0.05$ levels, respectively, when compared to the control group.

Conclusion: Children with ADHD displayed more deficits in the ToM inventory and tasks than children having SLD and healthy children of their similar age and educational background. Executive functions (set-shifting and response inhibition) were poorer in children with ADHD and children with SLD when compared to healthy children of their similar age and educational background.

Keywords: Theory of mind, attention deficit hyperactivity disorder, specific learning

disorder, executive functions, social cognition

Key Message: Theory of mind (ToM) is an important aspect of social competence. Poorer executive functions and ToM are seen in children with attention deficit hyperactive disorder (ADHD) or specific learning disorder (SLD). Therefore, interventions in social competence in children with ADHD and SLD may have beneficial results in their social life.

Attention deficit hyperactivity disorder (ADHD) is one of the commonest disorders affecting children. It affects up to 5% to 8% of school-aged children. Out of these, more than two-thirds have the disorder in adolescence and up to 60% meet the diagnosis in adulthood too.¹ Children with ADHD face many challenges in social situations because of their symptoms, that is, hyperactivity and impulsivity. Specific learning disorder (SLD) affects a substantial number of children. Children having SLD also face some difficulties in social behavior. One important aspect that is focused on in recent years, to understand

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the reason behind these difficulties, is the theory of mind (ToM).

ToM is defined as the ability to identify and ascribe thought processes, such as beliefs, desires, feelings, and intentions, to oneself and others.² ToM is one of the important constituents of social cognition³ ToM in humans develops gradually and depends on certain factors. Its development requires certain mechanisms and cognitive abilities. These are essential for ToM development and make one aware that others have a mind with various thought processes, including beliefs, plans, emotions, information, desires, and intentions. It also makes one understand that these thought processes can differ from one's own, and it is not necessary that everyone has the same thought process or feeling state at a particular time. ToM helps us not only to understand but also to predict the behavior of others. ToM is an important component required for proper and meaningful social cooperation and communication.⁴

Several executive functions (EFs), such as processes of analysis, inference, deduction, and estimation, are important for the development of ToM. Also, some of the components of ToM co-develop with EFs.⁵ The relation between EFs and ToM may involve specific processes of EF like inhibition and/or working memory capacity, or it may be a function of intellectual ability.⁶

EFs cause severe problems in social interaction in children with ADHD. Given the intricate relationship between EF and ToM development, children with ADHD fail in some tests of ToM and display impairments involving emotion and face and prosody perception, and reduced empathy. It is likely that their impulsivity and lack of ability to focus attention, and the behavioral problems that these give rise to, hinder ToM development in children with ADHD.⁷

SLD also is associated with deficits in EF, which contribute significantly to the academic and social difficulties faced by children with SLD. Children with SLD have difficulty controlling their impulses and organizing, prioritizing, and coordinating the information they receive. Significant deficits are encountered in working memory, self-regulation, and meta-cognitive skills. The malfunctions in executive skills significantly affect

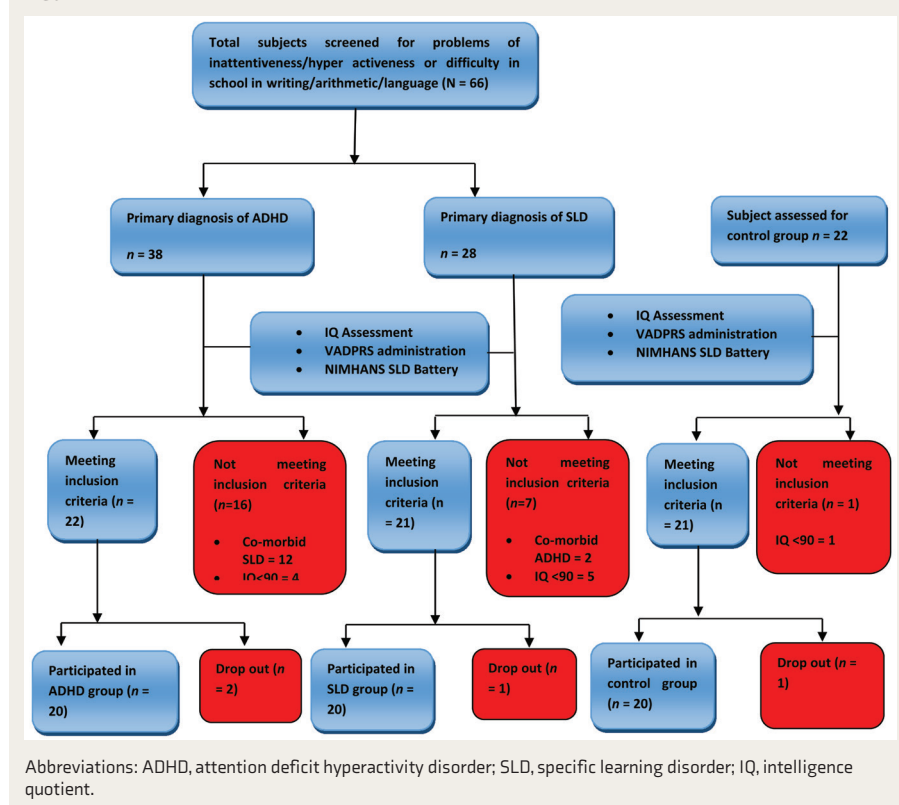
students with SLD in their academic, psychological, and social pathways and can lead to impaired ToM, and thus, similar behavioral problems as seen in ADHD are also encountered in SLD.^{8,9,10} Children with SLD demonstrated worse performance on the tasks that evaluated the ToM.¹¹

After reviewing the literature, it is seen that both ADHD and SLD are associated with EF impairment. Also, there is some relationship between EF and ToM which is still debatable, and for which further investigation is required. There is also a paucity of literature comparing ADHD and SLD based on the ToM and EF. Moreover, most of the literature is localized to only some parts of the world, and there is no study from India regarding the ToM in children having SLD and ADHD. SLD and ADHD are two different psychiatric disorders in children that have been investigated to have dysfunctions in executive functioning and social cognition; so it is worth comparing these two disorders to see whether any differences exist concerning ToM in children with ADHD and SLD. Hence, the present study is an attempt to investigate the ToM and EF differences, if any, in children suffering from ADHD or SLD.

Methods

It was a cross-sectional observational study. The total sample was of 60 students studying in classes from second to ninth, comprising three groups of 20 children each: (a) ADHD group: children having ADHD, (b) SLD group: children having SLD, and (c) Control group: healthy children of age range 7 to 15 years; of any gender and having average intelligence scores in Raven's Progressive Matrices, which includes standard progressive matrices (SPM) and colored progressive matrices (CPM). The study was conducted in a tertiary care hospital, Government Medical College and Hospital, Chandigarh, on an outpatient basis in the Department of Psychiatry, after approval from the institutional research and ethics committee. Data were collected from January 2015 to July 2016. Children in the age group 7 to 15 years, diagnosed with ADHD or SLD as per the *Diagnostic and Statistical Manual of Mental Disorders* (fifth edition) (DSM 5)¹² diagnostic criteria, and regularly attending schools were included in the ADHD and SLD groups, respectively. All consecutive cases coming with complaints of hyperactivity, inattentiveness, or

FIGURE 1.



scholastic difficulties were screened. Consultant psychiatrist clinically examined the children and those having a co-morbid disorder of ADHD in SLD group and SLD in ADHD group, depression, conduct disorder, neurodevelopmental disorders, history of substance use, major medical or neurological illness, visual or hearing impairment, or cerebral palsy were excluded from all the three groups. Siblings or peers of the children in control groups were typically developing and had similar age range, attending regular school, similar IQ range on SPM or CPM test. From all subjects fulfilling inclusion and exclusion criteria, written consents from parents and assent from the children were obtained. Sociodemographic details such as age, gender, school (government or private), and grade of the class along with relevant history, like treatment history, were recorded on semi-structured pro forma (**Figure 1**).

Diagnosis was made using the DSM 5 diagnostic criteria and vanderbilt ADHD diagnostic parent rating scale (VADPRS)¹³ were applied to each subject in all the three groups. They were also assessed formally for SLD by a clinical psychologist using the NIMHANS index for SLD.¹⁴ Subjects were excluded if they screened positive on both VADPRS and NIMHANS index for SLD battery in study groups. In the control group, children were excluded if they were positive on either of the measures. After the initial assessment, children were assigned to their respective groups and were assessed for EFs and ToM by recording responses of children on ToM task battery, while their parents were asked to fill questionnaires in ToM inventory.

Tools

Screening Tools

1. Vanderbilt ADHD Diagnostic Parent Rating Scale¹³: It has 55 questions in total reported by the parents based on the behavior of their child. This scale allows the clinician to make a diagnosis of ADHD, oppositional defiant disorder (ODD), or conduct disorder and also to categorize ADHD into one of its subtypes. The whole scale has good internal consistency and reliability in all methods and samples, with the overall Cronbach's alpha ≥ 0.90 .
2. NIMHANS Index of Specific Learning Disabilities¹⁴: It is a battery of tests to assess attention, reading, writing, spellings, comprehension, arithmetic, visuomotor skills, auditory and visual memory of the children attending school.
3. Raven's Progressive Matrices (Standard Progressive Matrices and Color Progressive Matrices)¹⁵: This is a culture-free test of general intelligence in booklet form. It has a reliability of 0.95 and split-half reliability of 0.97.

Executive Functions

1. Wisconsin Card Sorting Test, Set shifting¹⁶: It is a measure of the ability to form abstract concepts, to shift and maintain set, and to utilize feedback and inhibitory control on interference. It contains four stimulus cards, 64 or 128 response cards, and a record form. Scoring is done according to form, color, and number. One hundred twenty-eight response cards have been used in the study.
2. Stroop's test, Response inhibition¹⁷: It is a test of inhibitory control or response inhibition.

Theory of Mind

1. Theory of Mind Inventory¹⁸
It is a questionnaire containing 42 questions tapping a wide range of social cognitive understandings. It is to be answered by parents/caregivers according to their child's behavior. Each item is given in the form of a statement (e.g., "My child understands whether someone hurts another on purpose or by accident" and the respondent has to indicate on a line with a mark on "definitely not," "probably not," "undecided," "probably," and "definitely." Each item indicates a particular dimension of the ToM and belongs to one of three empirically derived subscales (i.e., early, basic, and advanced). These subscales reflect a developmental progression in the ToM development. Scoring is done in the end, and the total score is calculated based on which the final assessment is to be done.
2. ToM Task Battery¹⁸
This consists of 15 test questions. These questions pertain to nine tasks (tasks A–I) that are presented as short vignettes. These are arranged

in ascending order of difficulty and represent a variety in terms of content and complexity, ranging from simpler tasks, like identifying facial expressions, to the ability to infer second-order false belief. The second-order false belief is the ability to understand a person's false belief toward another person's belief. The test questions are answered by the child, and the scoring is done based on the responses.

Early ToM signifies important ToM achievements in infancy and toddlerhood. The early ToM subtest captures skills such as sharing attention, basic emotion recognition, intentionality, and social referencing. By the age of four years, typically developing children demonstrate an understanding of meta-representation, and difficulty in gaining such skills can lead to deficits in ToM. Advanced ToM develops around six to eight years of age and entails the ability to make accurate social judgments, which is a particularly advanced skill.

Statistical Analysis

Data were entered into IBM statistical package for social sciences (SPSS) version 22 (Chicago, USA). Levene's test of homogeneity (equality of variance), Shapiro–Wilk test for normality, and analysis of Skewness and Kurtosis were conducted to ensure the homogeneity of the data. Analysis of variance was computed to find out the differences between and within the groups. To further know the differences, posthoc analysis and student's *t* test were applied.

Results

All students were studying in English medium schools and were from private schools except one student in the SLD group who was studying in a government school. Out of the 60 students, 42 were from Chandigarh tri-city area, 18 were from outside Chandigarh (three in ADHD, four in SLD, and 11 in control group) 14 children in the ADHD group were on medication (methylphenidate or atomoxetine), which was stopped one day before testing for EFs and ToM.

No statistically significant differences were found between the groups for age ($F = 2.41, P > 0.05$) or gender (chi-square

= 0.89, $P > 0.05$). Significant differences were found in intelligence quotients ($F = 10.92$, $P < 0.01$) when ADHD and SLD groups were compared with the control group (Table 1).

In the ToM inventory, there were significant differences on early ToM, basic ToM, advanced ToM, and mean scores on ToM inventory between ADHD and control groups ($P \leq 0.001$). Similarly, significant differences were found between ADHD and SLD groups on early, basic, advanced, and mean ToM inventory

scores ($P < 0.001$). No significant differences were found between the control group and the SLD group on ToM measures. Further, in the ToM task battery, on task D and task G, significant differences were found between the SLD and control groups at $P < 0.05$ and $P < 0.05$, respectively. Differences between ADHD and control groups were statistically significant on task D and task G at $P < 0.001$ and $P < 0.05$, respectively (Table 2). Student's t test was employed to compare the groups for EFs; results indicate

statistically significant differences in all variables of Wisconsin card sorting test (WCST) except the number of conceptual level responses and Stroop's test (Table 3). On comparing the ADHD group with the SLD group for EFs on WCST and Stroop's test, significant differences were found on the number of correct responses and the number of category completed (Table 4). While comparing the ADHD and control groups, significant differences were found on the number of trials, number of

TABLE 1.

Age, Intelligence Quotient and Sex with Significant Differences Among Groups

Variable	ADHD (n = 20)	SLD (n = 20)	Control (n = 20)	F Values	Significance
Age (mean \pm SD)	10.0 \pm 2.29	11.45 \pm 2.18	11.35 \pm 2.51	$F = 2.41$	0.09
Sex (frequencies)	Male	17	15	Chi-square 0.89	0.64
	Female	3	5		
IQ (mean \pm SD)	100.85 \pm 6.72	101.35 \pm 6.76	109.35 \pm 5.84	$F = 10.92^{**}$	0.001
ADHD-Control	Posthoc analysis			$t = 13.41^{**}$	0.001
SLD-Control				$t = 12.91^{**}$	0.001
ADHD-SLD				$t = 5.41$	0.97

*Significant at $P < 0.05$, ** at $P < 0.01$.

ADHD, attention deficit hyperactivity disorder; SLD, specific learning disability.

TABLE 2.

Comparison of ToM Task Inventory and ToM Task Battery Between the Groups

ToM Measures	Groups	F Test	Posthoc Comparisons		
			Mean Difference	Standard Error	Significance
Early ToM mean score	ADHD-SLD	28.30**	-.97*	0.14	<0.001*
	SLD-Control		0.03	0.14	1
	Control-ADHD		.94*	0.14	<0.001*
Basic ToM mean score	ADHD-SLD	18.80**	-.49*	0.09	<0.001*
	SLD-Control		-0.05	0.09	1
	Control-ADHD		.55*	0.09	<0.001*
Advanced ToM mean score	ADHD-SLD	17.73**	-1.57*	0.32	<0.001*
	SLD-Control		-0.18	0.32	1
	Control-ADHD		1.76*	0.32	<0.001*
ToM inventory mean score	ADHD-SLD	22.30**	-.98*	0.17	<0.001*
	SLD-Control		-0.09	0.17	1
	Control-ADHD		1.07*	0.17	<0.001**
Task D	ADHD-SLD	9.05**	-0.3	0.17	0.29
	SLD-Control		-.45*	0.17	0.04*
	Control-ADHD		.75*	0.17	<0.001**
Task E	ADHD-SLD	1.06	0	0.07	1
	SLD-Control		-0.1	0.07	0.64
	Control-ADHD		0.1	0.07	0.64
Task F	ADHD-SLD	1.2	-0.15	0.13	0.81
	SLD-Control		-0.05	0.13	1
	Control-ADHD		0.2	0.13	0.43

(Table 2 continued)

(Table 2 continued)

ToM Measures	Groups	F Test	Posthoc Comparisons		
			Mean Difference	Standard Error	Significance
Task G	ADHD-SLD	4.61*	0	0.19	1
	SLD-Control		-.50*	0.19	0.03*
	Control-ADHD		.50*	0.19	0.03*
Task I	ADHD-SLD	2.99	-0.2	0.14	0.51
	SLD-Control		-0.15	0.14	0.9
	Control-ADHD		0.35	0.14	0.05

*Significant at $P < 0.05$, ** at $P < 0.01$.

† ADHD, attention deficit hyperactivity disorder, ToM, theory of mind, SLD, specific learning disorder.

TABLE 3.

t-Test Analysis on WCST and Stroop's Test Between ADHD, SLD, and Control Groups

Executive Functions (Set-Shifting and Response Inhibition)	ADHD (n = 20) Mean (SD)	SLD (n = 20) Mean (SD)	Control (n = 20) Mean (SD)	Between Groups Comparisons	t Scores	Significance (Two-Tailed)
No. of trials	123 (8.88)	117.25 (15.73)	89.45 (16.12)	ADHD-SLD	1.42	.163
				SLD-Control	5.51**	<0.001
				Control-ADHD	8.14**	<0.001
No. of correct responses	69 (19.10)	80.80 (7.7)	65.95 (3.11)	ADHD-SLD	-2.55*	.015
				SLD-Control	7.98**	<0.001
				Control-ADHD	.71	.48
No. Of perseverative responses	24.1 (8.08)	20.6 (8.26)	14 (7.85)	ADHD-SLD	1.35	.18
				SLD-Control	2.58*	.01
				Control-ADHD	4.00**	<0.001
No. of category completed	4.20 (1.96)	5.35 (.74)	5.8 (.61)	ADHD-SLD	-2.45*	.02
				SLD-Control	-2.08*	.04
				Control-ADHD	-3.47**	<0.001
No. of conceptual level responses	46.30 (28.88)	59.55 (24.02)	60.35 (6.3)	ADHD-SLD	-1.57	.12
				SLD-Control	-.14	.89
				Control-ADHD	-2.12*	.040
Failure to maintain set	.85 (.74)	.95 (.60)	.10 (.30)	ADHD-SLD	-.46	.64
				SLD-Control	5.60**	<0.001
				Control-ADHD	4.16**	<0.001
Stroop's test	221.55 (78.49)	178 (63.59)	141.20 (52.41)	ADHD-SLD	1.92	.06
				SLD-Control	1.99*	.05
				Control-ADHD	3.80**	<0.001

*Significant at $P < 0.05$, ** at $P < 0.01$.

WCST, Wisconsin card sorting test; SLD, specific learning disorder; ADHD, attention deficit hyperactivity disorder; SLD, specific learning disorder.

TABLE 4.

Posthoc Comparisons of WCST and Stroop Test Between the Groups

Executive Functions (Set-Shifting and Response Inhibition)	Groups	Posthoc Comparisons		
		Mean Difference	Standard Error	Significance
No. of trials	ADHD-SLD	5.75	4.42	0.59
	SLD-Control	27.80*	4.42	<0.001**
	Control-ADHD	-33.50*	4.42	<0.001**
No. of correct responses	ADHD-SLD	-11.75*	3.80	0.009**
	SLD-Control	14.85*	3.80	0.01**
	Control-ADHD	-3.1	3.80	1

(Table 4 continued)

(Table 4 continued)

Executive Functions (Set-Shifting and Response Inhibition)	Groups	Posthoc Comparisons		
		Mean Difference	Standard Error	Significance
No. of perseverative responses	ADHD-SLD	3.5	2.55	0.53
	SLD-Control	6.60*	2.55	0.04*
	Control-ADHD	10.10*	2.55	0.001**
No. of category completed	ADHD-SLD	-1.15*	0.40	0.02*
	SLD-Control	-0.45	0.40	0.79
	Control-ADHD	1.60*	0.40	0.001**
No. of conceptual level responses	ADHD-SLD	-13.25	6.96	0.19
	SLD-Control	-0.8	6.96	1
	Control-ADHD	14.05	6.96	0.14
Failure to maintain set	ADHD-SLD	-0.1	0.18	1
	SLD-Control	0.85*	0.18	<0.001*
	Control-ADHD	-.75*	0.18	<0.001*
Stroop's test	ADHD-SLD	43.55	20.78	0.12
	SLD-Control	36.8	20.78	0.25
	Control-ADHD	-80.35*	20.78	0.001**

*Significant at $P < 0.05$, ** at $P < 0.01$.

ADHD, attention deficit hyperactivity disorder; SLD, specific learning disorder.

perseverative responses, number of categories completed, number of conceptual level responses, failure to maintain set, and on Stroop's test (Table 4). Further, when the SLD group and control group were compared, significant differences were found in the number of trials, number of correct responses, number of perseverative responses, number of categories completed, and failure to maintain set. EFs in the form of set-shifting and response inhibition were significantly poor in the ADHD group and SLD group when compared to the control group.

Discussion

This study examined the difference in ToM and EFs between children with ADHD or SLD and normal healthy children. There were no statistically significant differences between the ADHD and SLD groups when compared for age and gender. Intelligence scores were significantly higher in the control group in comparison to the ADHD group and SLD group, although intelligence scores were within the average range of intelligence (90 to 110) in the control, ADHD, and SLD groups. This suggests that even though the IQ of the control group is statistically higher when compared to ADHD and SLD groups, the classification of intelligence has kept all the three groups into the same category of average intelligence. Still, the possible confounding

impact of intelligence on the ToM and executive functioning among children in ADHD and SLD groups cannot be ruled out.

Executive Function in ADHD and SLD

Two tests were administered to study the EFs, in the form of set-shifting and response inhibition ability. While comparing the ADHD and SLD groups, findings on WCST suggest that the number of correct responses and the number of categories completed were significantly more in the SLD group than the ADHD group. These findings emphasize that EFs of set-shifting and response-inhibition abilities are significantly affected in both ADHD and SLD, but more in ADHD, than healthy controls. The malfunctions in executive skills significantly affect students with learning difficulties in their academic, psychological and social pathways and can lead to impaired ToM. Similar problems as seen in ADHD are also encountered in SLD.⁸⁻¹⁰

ToM in ADHD and SLD

In the ToM task battery, also, there was a significant difference between ADHD and SLD groups from the control group in line of sight task and belief- and reality-based emotion and second-order emotion task, again implicating some deficits in ToM

of children in ADHD and SLD groups. The line of sight task assesses the fact that people may see differently depending on position. Belief- and reality-based emotion and second-order emotion task tests assess whether a child understands that beliefs and events contradictory to what one thinks can cause emotions. Deficits in these tasks indicate some difficulty acquiring or learning such skills, which can be attributed to the difficulty in learning (SLD) and ADHD.

We found deficits in ToM in ADHD, and SLD compared to healthy controls, though deficits were more in children with ADHD. Some previous studies found no difference in ToM in ADHD and healthy controls,¹⁹ while some have shown deficits in ToM in ADHD.^{20,21} Thus, our findings support the finding of previous studies.^{20,21} This study also showed deficits in ToM in children with SLD. This finding supports the previous studies in which children diagnosed with SLD demonstrated worse performance on the tasks that evaluated ToM. It was determined that children with SLD had challenges in ToM.¹¹ Because EFs are also impaired in ADHD and SLD groups, EFs can have an important role in the deficits in ToM in children with ADHD and SLD.

It implies that EF deficits are likely to be trait deficits in ADHD and SLD, as the findings suggest; hence, it emphasizes

a need to address these deficits by specific remediation, which can help in improving these deficits with specific cognitive retraining techniques. There is a possibility of a relationship between ToM and EF, though the degree of prediction and predictability of one over the other cannot yet be established because of the studies' heterogeneity. Still, this emphasizes the need to address the deficits in EFs and their relationship with ToM.²²

Children with ADHD had deficits in early ToM, indicating difficulty in such skills. Basic ToM pertains to advancements characteristic of typically developing preschool children. Again, children with ADHD have significant deficits indicating lack of certain skills, which causes certain behavioral problems such as irritability and difficulty in understanding social cues.

Advanced ToM develops at around six to eight years of age and entails the ability to make accurate social judgments, which is a particularly advanced skill. Deficits in such skills lead to behavioral problems as the child cannot make social judgment involving becoming aware of mental states and attitudes that may be apparent in subtle social cues. Inability to understand the relation of these cues to the physical and social environment and to modify their behavior after extracting meaningful and relevant information leads to behavioral problems. A recent meta-analysis had found that ToM training procedures can effectively enhance ToM in children.²³

This study has the limitation of a small sample size. ADHD children were not further divided into inattentive, hyperactive, and combined subtypes. The control group comprised siblings of children with ADHD or SLD. The severity of ADHD was not considered. Some children from the ADHD group were on medication, though the medication was stopped a day before testing. EFs are assessed through two tests; a full battery of EFs might give a better picture of executive functioning. So, further studies are required with a larger sample size in different subgroups of ADHD, overcoming these limitations.

Conclusion

Children with ADHD have more deficits in the ToM inventory and tasks than children having SLD and healthy children of similar age and education. EFs

(set-shifting and response inhibition) were poor in children with ADHD and in children with SLD compared to healthy children of their age and education.

Declaration of Conflicting Interests

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