

Cluttering and Working Memory in Attention Deficit and Hyperactivity Disorder

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ABSTRACT

Background: This study aims to explore cluttering and working memory in children and adolescents diagnosed with different subtypes of Attention Deficit Hyperactivity Disorder (ADHD) and to compare them with typically developing (TD) children and adolescents.

Methods: The sample included 200 ADHD participants and a control group of 49 TD participants. All participants completed the Working Memory Scale and Predictive Cluttering Inventory-revised (. Data were analyzed using SPSS, and Mann-Whitney *U* and Kruskal-Wallis tests were performed to assess differences between the groups. A significance level of $P < .05$ was used for all analyses.

Results: Significant differences were observed in the Working Memory, Visual Memory, and Verbal Memory scores across the Typically Developed ADHD-Inattentive type and ADHD-Combined type groups ($P < .001$). Additionally, there were significant differences in the PCI-TR scores, including motor speech, language planning, attention, motor planning, and total scores, between the 3 groups. The findings indicated significant differences between the groups across all variables ($p < .001$).

Conclusion: The study concluded that cluttering is present in both the ADHD Inattentive and Combined types. It is recommended that children diagnosed with ADHD undergo more comprehensive assessments of their language and speech capabilities.

ARTICLE HISTORY

Received: November 19, 2024

Revision Requested: January 4, 2025

Last Revision Received: March 12, 2025

Accepted: April 2, 2025

Publication Date: April 28, 2025

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that typically persists into adolescence and adulthood after beginning in early childhood. A person's development, health, and academic performance are all adversely impacted by ADHD. According to the American Psychiatric Association (APA), 3%-7% of school-age children have ADHD.¹ It is estimated that ADHD affects 2.5% of adults and 8.4% of children.^{2,3}

Attention-Deficit/Hyperactivity Disorder (ADHD) is characterized by symptoms such as inattention, hyperactivity, and impulsivity. There are 3 subtypes of ADHD. The predominantly inattentive type of ADHD is characterized by symptoms of inattention rather than hyperactivity or impulsivity. Individuals with this type typically demonstrate difficulty in sustaining attention, organizing tasks, following through with instructions, and maintaining focus over extended periods. Attention-Deficit/Hyperactivity Disorder Combined Type is characterized by a mixture of inattention and hyperactive-impulsive symptoms, including excessive talking.¹

One of the less commonly discussed aspects of ADHD is its effect on speech patterns, including speech rate. Research suggests that individuals with ADHD, especially those with the hyperactive-impulsive subtype, may demonstrate an increased speech rate compared to those without the disorder. This rapid speech is often associated with impulsivity, where individuals feel the need to express their thoughts quickly, often without pauses or delays.³

Along with an accelerated rate, individuals with ADHD may also exhibit more speech disfluencies, such as frequent interruptions, unfinished sentences, or tangential speech. These disfluencies can result from deficits in attentional control and cognitive processing, leading to difficulties in maintaining a coherent flow of speech.⁴

It is also important to note that speech rate in individuals with ADHD can vary significantly depending on factors like task demands, emotional state, and the presence of co-occurring conditions like anxiety or depression. Research indicates that while some individuals may speak rapidly in a less controlled manner, others may show variability

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Cite this article as: Fidan ST, Sarıyer MN. Cluttering and working memory in attention deficit and hyperactivity disorder. *Psychiatry Clin Psychopharmacol*. Published online April 28, 2025. doi: 10.5152/pcp.2025.241035.



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in their rate, sometimes slowing down when experiencing fatigue or stress.⁵

When individuals with ADHD are engaged in tasks requiring significant cognitive effort, such as multitasking or organizing thoughts, their speech rate may occasionally slow down. This occurs because the individual has to allocate more cognitive resources to the task at hand, reducing their ability to produce fluent, rapid speech.⁴

Individuals with ADHD may exhibit cluttering due to impulsivity and attentional issues, but this can vary greatly depending on the context and cognitive load. The increased rate of speech is often coupled with disfluencies and can be influenced by emotional states or co-occurring conditions.⁶

The speech fluency is affected both in cluttering and stuttering. Cluttering involves rapid, disorganized speech with little awareness or tension, while stuttering is marked by involuntary interruptions such as blocks and repetitions, with noticeable struggle and awareness of the issue.⁷

Working memory (WM), a cognitive system responsible for temporarily holding and manipulating information, plays a crucial role in speech production, especially in conditions like ADHD. Research suggests that individuals with ADHD often have deficits in working memory, which can contribute to difficulties in organizing thoughts and articulating them clearly and coherently. This dysfunction can lead to cluttered and fragmented speech patterns often observed in ADHD.⁸

To the authors' knowledge, in the literature there are few studies about cluttering and ADHD. Therefore, this study aims to examine cluttering among children and adolescents diagnosed with ADHD subtypes and to investigate potential differences between ADHD subtypes and typically developing (TD) children and adolescents. Also, the study aims to explore the relationship between working memory, cluttering, and ADHD subtypes, specifically ADHD-Inattentive Type and ADHD-Combined Type.

MATERIALS AND METHOD

Participants

We used G*Power analysis, assuming a medium effect size for Cohen's f (0.25) and 3 groups; for each group, 30-40

participants can be recommended.⁹ The research sample consisted of 249 participants: 99 (39.8%) girls and 150 (60.2%) boys, aged between 6 and 17 years ($\text{mean} = 9.44 \pm 2.33$). While 137 (55%) had a diagnosis of combined type, 63 (25.3%) had attention deficit dominant type, and 49 (19.7%) of the participants were TD children who were Turkish speakers. Demographic findings about the participants are presented in Table 1.

Inclusion criteria for the ADHD groups were a diagnosis of either attention deficit inattentive type or combined type, having no additional diagnosis (autism, anxiety disorder, learning disorders, language disorders, hearing impairment, etc.), an IQ score of 85 or above, and having ongoing treatment in a child and adolescent psychiatry outpatient clinic. All children and adolescents with ADHD were diagnosed and evaluated for differential mental disorders using the Diagnostic and Statistical Manual of Mental Disorders (DSM-V)¹ by a child and adolescent psychiatrist. The Wechsler Intelligence Scale for Children (WISC-R),¹⁰ Learning Disability Battery,¹¹ Autism Rating Scale for Children (CARS-2),¹² and Test of Language Development test-Turkish version (TODIL)¹³ were administered when necessary for differential diagnosis. Likewise, inclusion criteria for the typically developed group stipulated that the children had an IQ score of 85 or above, no additional mental diagnosis, and no health problems. Typically developing children with age-appropriate developmental levels in cognitive, motor, speech and language, and social-emotional areas were included the study.¹⁴

Exclusion criteria for the ADHD study were individuals with a history of neurological disorders or serious medical conditions that could impact cognitive or developmental functioning. Those diagnosed with severe psychiatric disorders (schizophrenia, bipolar disorder, autism, learning disorder, etc.) that might affect the study's assessment or results were also excluded. Additionally, children with an IQ below 85, indicating intellectual disability, were not included. Participants who were not receiving proper care or treatment for their diagnosed conditions were also excluded. Lastly, children or parents who were unable or

Table 1. Demographic Findings of the Participants

Variables		Min-Max	Median
Age		6-17	9.00
Variables		n	%
Gender	Female	99	39.8
	Male	150	60.2
Group	TD	49	19.7
	ADHD combined type	63	25.3
	ADHD inattentive type	137	55.0
Total		249	100.0

ADHD, attention-deficit/hyperactivity disorder; TD, typically developing.

MAIN POINTS

- Attention Deficit Hyperactivity Disorder is a neurodevelopmental disorder that starts in early childhood and tends to continue into adolescence and adulthood.
- It affects individuals' lives in all aspects. One of them is speech and language.
- In clinical settings, detailed speech and language assessments are required.
- In the diagnosis process, speech, language, and communication skills should be assessed.

unwilling to provide informed consent for participation were deemed ineligible.

Instruments

Predictive Cluttering Inventory-r¹⁵ and Working Memory Scale¹⁶ were used to assess participants' working memory performance and fluency respectively.

Predictive Cluttering Inventory-r

Predictive Cluttering Inventory-revised¹⁵ was performed for the assessment of children with ADHD. The results of internal consistency, test-retest, and inter-rater reliability of both the PCI-r and the ADI-r support that both assessment tools are valid and reliable tests that can be used as clinical tools to collect information, predict, and provide guidance regarding symptoms of ADHD. The PCI-r met the content validity criterion. Furthermore, the PCI-r was found to be a reliable tool, as shown by $\alpha > 0.70$ and Intraclass Correlation Coefficient (ICC) values between 0.75 and 0.90. The inventory has 4 subsections: Section 1 Motor Speech, Section 2 Language Planning, Section 3 Attention, and Section 4 Motor Planning. All the participants were asked to talk about their last summer vacation for 10 minutes. Very few participants were reluctant to speak about their holidays, so the authors encouraged them by speaking about their own holidays.

Working Memory Assessment

Working Memory Scale¹⁶ was utilized to assess working memory. The test consists of 4 main subtests: Verbal Short-Term Memory, Visual Short-Term Memory, Verbal Working Memory, and Visual Working Memory.

Ethical Consideration

The study was carried out at Eskisehir Osmangazi University Child and Adolescent Psychiatry outpatient clinic following the ethical approval from Anadolu University Research Ethics Committee (No. 503516). The "Informed Consent Form" was signed by the parents or legal custodians of the participants. Demographic and developmental information regarding the participants was collected from the parents or caregivers.

Data Collection Procedures

Working Memory Scale and PCI-r inventory were administered to those who met the inclusion criteria, voluntarily agreed to participate in the study, and whose follow-up and treatment were continuing in the Child Psychiatry outpatient clinic. In the PCI-r inventory, the participants were asked to share their last summer experience with the researcher(s) for 2-3 minutes. The Working Memory Scale was utilized to assess working memory. The tasks were given orally. This research was conducted according to the principles outlined in the Helsinki Declaration 2008.

Statistical Analysis

The data were analyzed using IBM SPSS Statistics for Windows, Version 25.0 (IBM SPSS Corp.; Armonk, NY, USA).¹⁷ The frequencies, percentages, means, and SDs of the individuals in the groups were presented using descriptive statistics for various variables. For continuous variables, the highest and lowest values, mean, and SD were calculated, while for categorical variables, frequencies and percentages were determined. To test whether the data met the assumption of normality, Kolmogorov-Smirnov tests, skewness and kurtosis values, histograms, and Q-Q plots were examined. In comparisons between groups, when there were 2 groups, independent t-tests and Mann-Whitney *U* tests were used, while Kruskal-Wallis *H* analysis was applied for 3 or more groups. When a significant difference was found between groups, Mann-Whitney *U* analysis was also conducted for pairwise comparisons to identify the source of the difference. The relationships between variables were tested using the Pearson correlation coefficient. A logistic regression model was conducted to examine the influence of age, gender, medication use, and groups including ADHD subtypes and TD on the PCI-r scores. When the PCI-r scores were taken as the dependent variable, the effects of independent variables (gender, age, medication, and groups—Inattentive Type and Combined Type—on the PCI-r score were evaluated in logistic regression analysis). In this study population, the median PCI-r scores were 115. A logistic model was devised based on this reference category where those who scored less than 115 points on the PCI-r test were ascribed as "0" and those who scored more than 115 points on the test were ascribed as "1." The significance level for all analyses was set at $P < .05$.

RESULTS

The lowest and highest values, mean and SD values of the participants' motor speech, language planning, attention, motor planning and total scores are presented in Table 2. As shown in Table 2, TD children's mean scores for motor speech, language planning, and motor planning were zero. Only attention and total score means were 0.12 ± 0.63 .

Whether there was a significant difference between drug use and the motor speech, language planning, attention, motor planning and total scores of the participants was examined through a t-test conducted for 5 separate independent groups. The results showed that there was no statistically significant difference between the groups in terms of the mean scores of the variables ($P > .05$). The findings are presented in Table 3.

Three separate Kruskal-Wallis *H* analyses were conducted to examine whether there was a significant difference in the mean working memory, verbal memory, and visual memory scores between the TD, ADHD-Inattentive type and ADHD-Combined type. The results indicated a significant difference in the rank means of the groups for all 3 variables

Table 2. The Participants' Minimum and Maximum Values, Median Values Across Motor Speech, Language Planning, Attention, Motor Planning, and Total Scores

Group	Variables	n	Min-Max	Median
TD	Motor speech	49	0-0	.00
	Language planning	49	0-0	.00
	Attention	49	0-4	.91
	Motor planning	49	0-0	.00
	Total score	49	0-4	.91
ADHD inattentive type	Motor speech	63	5-70	45.00
	Language planning	63	10-40	25.00
	Attention	63	0-45	35.00
	Motor planning	63	10-30	20.00
	Total score	63	65-167	120.00
ADHD combined type	Motor speech	137	6-70	45.00
	Language planning	137	1-40	25.00
	Attention	137	0-45	35.00
	Motor planning	137	0-25	20.00
	Total score	137	16-167	120.00

ADHD, attention- deficit / hyperactivity disorder; TD, typically developing.

(respectively, $\chi^2(2)=55.931$, $P < .001$; $\chi^2(2)=70.021$, $P < .001$; $\chi^2(2)=64.407$, $P < .001$). To investigate the source of the difference, pairwise comparison analyses were conducted. The results revealed that the TD group had significantly higher mean scores in all 3 types of memory compared to both the ADHD-Inattentive type and ADHD-Combined type ($P < .001$). The findings are presented in Table 4 and Figure 1.

Five separate Kruskal-Wallis H analyses were conducted to examine whether there was a significant difference in the motor speech, language planning, attention, motor planning, and total scores between the ADHD-Inattentive type and ADHD-Combined type, and TD participants. The results showed a significant difference in the rank means of

Table 3. The Difference Between Medication and PCI-r Scores

Variables	Drug Use	n	Median (Q1-Q3)	P
Motor speech	No	26	46 (46-54)	.372
	Yes	174	45 (35-50)	
Language planning	No	26	26(20-35)	.226
	Yes	174	25 (20-30)	
Attention	No	26	31(25-40)	.612
	Yes	174	35 (25-40)	
Motor planning	No	26	20 (15-25)	.751
	Yes	174	20 (15-25)	
Total score	No	26	122.50 (110-137)	.433
	Yes	174	120 (109-137.5)	

$P < .05$.

PCI-r, predictive cluttering inventory-revised.

the groups for all variables (respectively, $\chi^2(2)=119.531$, $P < 0.001$; $\chi^2(2)=122.009$, $P < .001$; $\chi^2(2)=116.580$, $P < .001$; $\chi^2(2)=120.730$, $P < .001$; $\chi^2(2)=118.674$, $P < .001$). A pairwise comparison analysis was conducted to investigate the source of the difference, and it was found that for all variables, the TD participants had significantly lower mean scores compared to both the ADHD-Inattentive type and ADHD-Combined type ($P < .001$). The findings are presented in Table 5 and Figure 2.

A logistic regression model was conducted to examine the influence of age, gender, medication use, and groups including ADHD subtypes and TD on the PCI-r scores. The logistic regression analysis reveals that none of the predictor variables (age, gender, medication use, or groups including ADHD subtypes and TD) are statistically significant predictors of the PCI-r scores ($P < .05$). (Table 6).

DISCUSSION

This study consists of 249 children and adolescents aged between 6 and 17, with a mean age of 9.44 ± 2.33 . About 200 children and adolescents with ADHD, who were diagnosed with ADHD combined type ($n=137$, 55%) and inattentive type ($n=63$, 25.3%), together with their sex- and age-matched 49 TD peers as the control group, were examined.

In this study, cluttering was explored using the PCI-r (Predictive Cluttering Inventory revised) among children and adolescents diagnosed with ADHD, as well as their TD peers. The PCI-r scores for the TD group were lower across motor speech, language planning, attention, motor planning, and total subtests. Table 2 illustrates that all cluttering scores were higher in the ADHD subgroups compared to the TD control group. The cluttering scores in ADHD subgroups were similar. In a previous study, it was found that approximately 14% of the ADHD population had speech sound disorders, and around 4% exhibited cluttering. The existing literature on cluttering in children and adolescents with ADHD is limited. Given that social deficits present a significant challenge in ADHD, assessing speech and language disorders is crucial for treatment. Cluttering is a relatively newly defined disorder, and distinguishing fast speech from cluttering, particularly in ADHD, remains unclear. As a result, many cases of speech and language disorders are often underdiagnosed. In this study, cluttering scores were higher in both Inattentive Type and Combined Type, having hyperactivity and impulsivity symptoms. From this perspective, impulsivity, executive dysfunction such as attention, and language processing deficits are all factors that could contribute to the development or exacerbation of cluttering in individuals with ADHD. In this study, only ADHD subtypes were examined and ADHD symptoms severity was not classified. The relationship between the severity of ADHD and cluttering formation

Table 4. Comparison of Working Memory, Verbal Memory, And Visual Memory means of Typically Developing, Inattentive Type, And Combined Type Participants

Memory Type	Groups	n	Median	S	Median (Q1-Q3)	χ^2	P	
Working memory	TD ^a	49	41.12	8.63	40 (34.5-45)	55,931	<.001*	IT ^b -TD ^a : $P < .001^*$ CT ^c -TD ^a : $P < .001^*$ IT ^b -CT ^c : $P = .644$
	Inattentive type ^b	63	24.21	13.76	19 (15-32)			
	Combined type ^b	137	24.20	15.44	19 (14.-25)			
	Total	249	27.53	15.42				
Verbal memory	TD ^a	49	24.86	5.11	25 (23-26)	70,021	<.001*	IT ^b -TD ^a : $P < .001^*$ CT ^c -TD ^a : $P < .001^*$ IT ^b -CT ^c : $P = .786$
	Inattentive type ^b	63	15.03	6.19	15 (10-20)			
	Combined type ^b	137	14.97	6.40	14 (5-11)			
	Total	249	16.93	7.25				
Visual memory	TD ^a	49	21.33	8.58	18 (14.5-25)	64,407	<.001*	IT ^b -TD ^a : $P < .001^*$ CT ^c -TD ^a : $P < .001^*$ IT ^b -CT ^c : $P = .631$
	Inattentive type ^b	63	9.60	6.75	10 (5-11)			
	Combined type ^b	137	10.35	8.76	6 (4.5-12)			
	Total	249	12.32	9.37				

Mann-Whitney U test was used.

TD, typically developing. IT^b, Inattentive type^b, Attention-deficit / hyperactivity disorder- inattentive type. CT^c, Combined type^c, Attention-deficit / hyperactivity disorder- combined type.

* $P < .001$.

has not been extensively studied in the literature. ADHD, particularly when symptoms are severe, often leads to difficulties in organization, task initiation, and time management, which are all factors contributing to cluttering in communication.

Impulsivity, a hallmark of ADHD, may cause individuals to speak quickly without pausing for thought, leading to disjointed or rushed speech patterns characteristic of cluttering. According to Barkley,⁴ impulsive behaviors in ADHD can impair the ability to organize thoughts before speaking, which may result in speech that lacks clarity or coherence. Furthermore, impulsivity may lead to an overwhelming volume of speech in a short time, increasing the likelihood of cluttering symptoms.

Executive dysfunction, which often co-occurs with ADHD, may also contribute to cluttering. Executive functions such as planning, organizing, and monitoring behavior are crucial for regulating speech flow and ensuring appropriate pacing.¹⁸ Impairments in these areas can lead to disorganized speech that lacks appropriate pauses, prosody, and structure, hallmark traits of cluttering. Moreover, executive dysfunction can hinder the individual's

ability to process information quickly, making it difficult to manage multiple verbal tasks simultaneously.

Additionally, language processing deficits are commonly observed in children with ADHD and may interact with attentional difficulties, exacerbating cluttering symptoms. Language processing involves the ability to comprehend and produce language efficiently, and deficits in this area can result in speech that is not only rapid but also grammatically incorrect or unclear (Lyon et al., 2001).¹⁹ Attention deficits, which are core to ADHD, could further impair the processing of verbal information, leading to a lack of clarity or cohesiveness in speech.

The neurocognitive mechanisms underlying cluttering may vary across ADHD subtypes. For instance, individuals with the Inattentive Type may exhibit more subtle executive dysfunction and attention deficits, which could affect their speech organization and fluency in less obvious ways than individuals with the Combined Type. The Combined Type, which includes both hyperactivity and impulsivity, often involves more significant impairments in executive functions and attention regulation, potentially leading to more pronounced cluttering symptoms.⁴

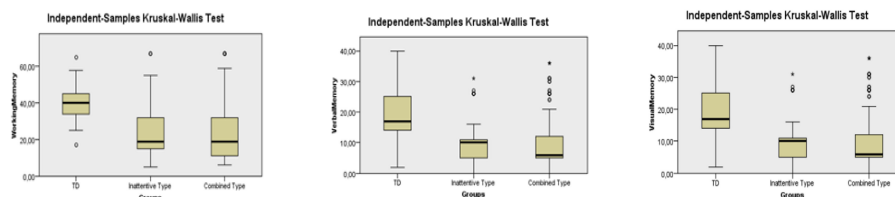


Figure 1. Comparison of scores of working memory, verbal memory, and visual memory averages between typically developing, attention-deficit/hyperactivity disorder-inattentive type and attention-deficit/hyperactivity disorder-combined type.

Table 5. PCI-TR Motor Speech, Language Planning, Attention, Motor Planning and Total Scores Between Attention-Deficit/Hyperactivity Disorder Subgroups

Variables	Groups	n	Mean	SD	Median (Q1-Q3)	χ^2	P	
Motor speech	TD ^a	49	.00	.000	0 (0-0)	119,531	<.001*	
	Inattentive type ^b	63	44.35	12.653	45(35-50)			IT ^b -TD ^a : $P < .001^*$ CT ^c -TD ^a : $P < .001^*$ IT ^b -CT ^c : $P = .946$
	Combined type ^c	137	44.28	12.636	45(35-50)			
Language planning	TD ^a	49	.00	.000	0 (0-0)	122,009	<.001*	
	Inattentive type ^b	63	24.06	7.427	25(20-30)			IT ^b -TD ^a : $P < .001^*$ CT ^c -TD ^a : $P < .001^*$ IT ^b -CT ^c : $P = .201$
	Combined type ^c	137	25.46	7.881	25(20-34.5)			
Attention	TD ^a	49	.12	.634	0 (0-0)	116,580	<.001*	
	Inattentive type ^b	63	32.08	9.171	35(25-40)			IT ^b -TD ^a : $P < .001^*$ CT ^c -TD ^a : $P < .001^*$ IT ^b -CT ^c : $P = .201$
	Combined type ^c	137	31.13	10.050	35(22.5-40)			
Motor planning	TD ^a	49	.00	.000	0 (0-0)	120,730	<.001*	
	Inattentive type ^b	63	20.33	5.093	20(15-25)			IT ^b -TD ^a : $P < .001^*$ CT ^c -TD ^a : $P < .001^*$ IT ^b -CT ^c : $P = .675$
	Combined type ^c	137	19.55	6.113	20(15-25)			
Total	TD ^a	49	.12	.634	0 (0-0)	118,674	<.001*	
	Inattentive type ^b	63	120.83	20.732	120(110-130)			IT ^b -TD ^a : $P < .001^*$ CT ^c -TD ^a : $P < .001^*$ IT ^b -CT ^c : $P = .918$
	Combined type ^c	137	120.42	23.561	120(108-135)			

Mann-Whitney U test was used.

TD^a, typically developed. IT^b, Inattentive type^b, Attention-deficit / hyperactivity disorder- inattentive type. CT^c, Combined type^c, Attention-deficit / hyperactivity disorder- combined type.

* $P < .001$.

¹⁹ In this study, cluttering was observed in both the Inattentive type of ADHD and the combined Inattentive and Hyperactivity-Impulsivity type of ADHD.

In this study, a statistically significant difference regarding medication use in the ADHD subgroups ($P \geq .05$) was not found. Although ADHD medications improve attention and concentration, they do not enhance all aspects of language abilities in children with ADHD. Language disorders related to semantics and pragmatics in ADHD may respond better to stimulant medications compared to language morphology, which is likely influenced by the ongoing effects of inattention, hyperactivity, and impulsivity that begin early in life and continue over time. As a result, a combination of treatments is recommended to help children with ADHD reach their full potential. In this study, all children and adolescents were asked to discuss their last summer vacation during the PCI-r assessment to evaluate their narrative skills. Furthermore, no change in narrative skills was observed with ADHD medical treatment in this study. After ADHD treatment, improvements in language and speech symptoms may be attributed to neurocognitive-based changes, but detailed assessments may still uncover lingering issues.²⁰ ADHD medication and its impact on

cluttering have not been extensively studied directly, but existing research on ADHD treatment, specifically stimulant medications, provides insights into how medication might influence symptoms of cluttering. ADHD medications, such as stimulants (e.g., methylphenidate and amphetamines), are commonly prescribed to manage inattention, impulsivity, and hyperactivity, which can indirectly impact behaviors related to cluttering, both in physical spaces and speech. In this study, the variables medication use, age, gender, and ADHD subtypes (Inattentive Type and Combined Type) showed weak associations with the PCI-TR scores, with P -values exceeding the conventional .05 threshold for statistical significance. Despite the negative and positive coefficients for some predictors, the odds ratios are very close to 1, which further suggests that these variables have only minimal effects on the PCI-TR scores. One potential explanation for the lack of statistically significant findings is the possibility that the model may not have accounted for other relevant factors that could influence PCI-TR scores. Moreover, the lack of statistically significant relationships between the predictors and the PCI-TR scores could also be due to the complexity of the outcome variable. The PCI-TR scores may be influenced by a wider range of factors that

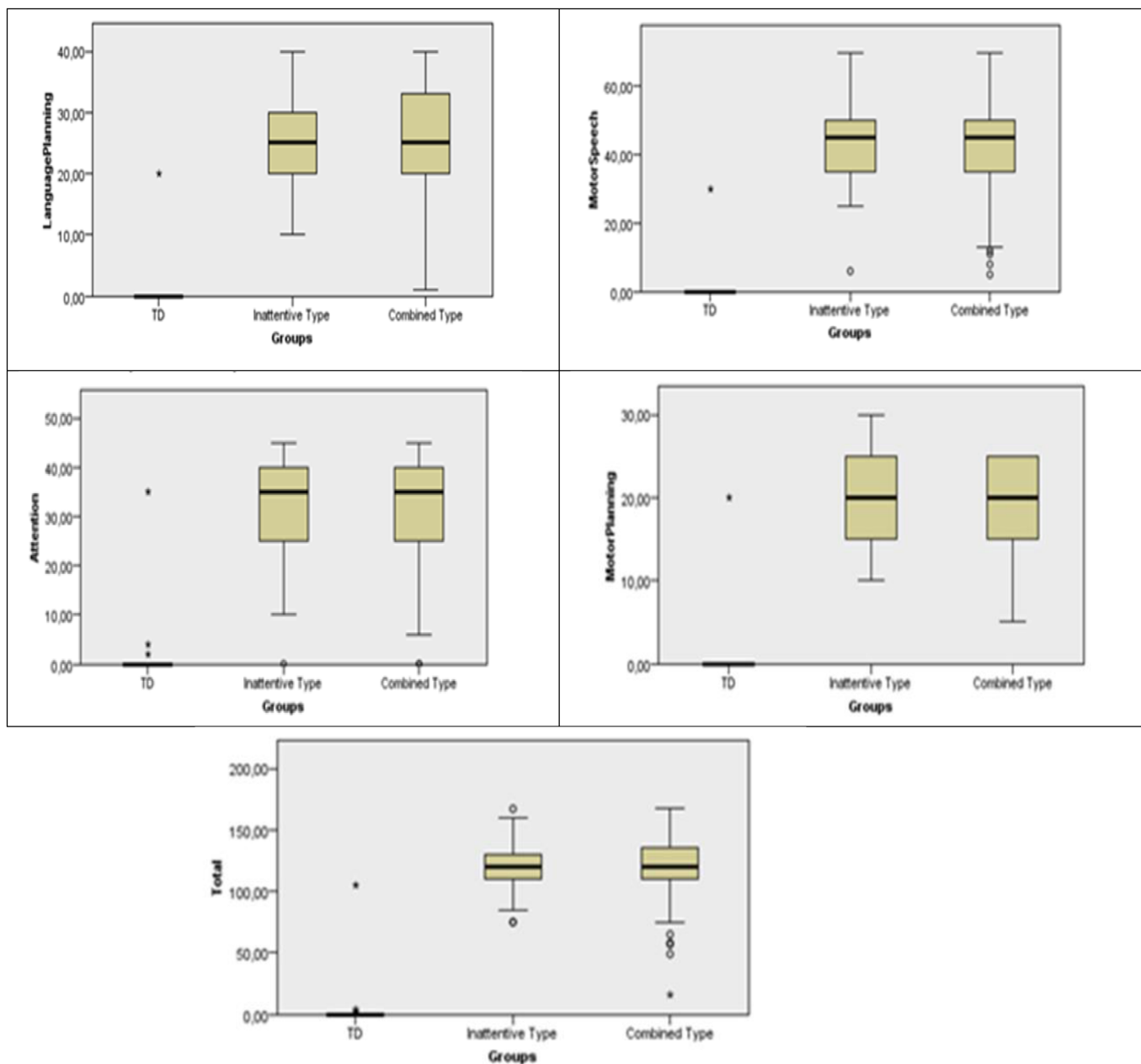


Figure 2. Comparison of scores of PCI-r subtests between typically developing, attention-deficit/hyperactivity disorder-inattentive type and attention-deficit/hyperactivity disorder-combined type.

are not captured by the variables included in this analysis. Future studies could focus on collecting a larger and more diverse sample, exploring additional potential predictors, and examining more complex models, including interactions and non-linear relationships, to better capture the factors influencing PCI-TR scores.

The neural correlates of cluttering are not well understood, but theoretical models suggest the involvement of the basal ganglia and medial prefrontal cortex. Dysfunction in these brain regions may contribute to difficulties in selecting and controlling speech motor programs, which are characteristic of the disfluencies observed in cluttering.

Table 6. The Effect of Demographic Characteristics on the PCI-TR Scores According to Logistic Regression Analysis

Variable	B	S.E.	Wald F	P	Exp(B)	95% CI
Age	-.090	0.060	2.254	.133	0.914	0.813-1.028
Gender	-.123	0.363	0.115	.734	0.084	0.434-1.801
Medication	-.182	0.448	0.165	.685	0.834	0.346-2.007
Groups	.008	0.377	.000	.984	1.008	0.481-2.111

Despite this, there has been a surprising lack of research on cluttering using modern imaging techniques.¹² It was emphasized that both combined type and inattentive type ADHD groups had impairments in working memory, verbal memory, and visual memory compared to typically developed child and adolescent control group. These findings were coherent with previous studies.² Numerous neurocognitive studies explore the connection between working memory and language and speech disorders in individuals with ADHD. Attention-Deficit/Hyperactivity Disorder is primarily associated with deficits in executive functions such as attention regulation, cognitive control, and working memory. These functions are crucial for managing speech production, ensuring coherence, and controlling speech rate. In those with ADHD, challenges in focusing and regulating attention often result in faster speech and difficulty staying on topic, which can lead to cluttering. The prefrontal cortex, which plays a vital role in managing attention and executive functions, is often found to be underactive or dysregulated in individuals with ADHD. This dysregulation affects their ability to plan and organize their thoughts before speaking, leading to disorganized speech and a tendency to speak quickly without fully thinking through their words. In this study, all subtypes exhibiting impairments in working memory and cluttering are connected to executive dysfunctions and related to difficulties in speech production and regulation.

Impulsivity, a hallmark of ADHD, can also manifest in speech patterns. Individuals with ADHD often speak impulsively, blurting out thoughts before they have fully processed or organized them, leading to rapid and disordered speech. This impulsive speaking behavior is directly linked to deficits in inhibitory control, a cognitive function regulated by the prefrontal cortex. Impulsive speech patterns can involve cluttering, jumping from one topic to another, and difficulty maintaining coherent conversations. These difficulties arise because individuals with ADHD may struggle to inhibit premature speech production or self-correct during conversations, resulting in cluttering.⁴

Speech production is a complex, goal-oriented activity, and many motor control theories emphasize the significance of precise temporal coordination between motor output and sensory perception. Motor hyperactivity is a common trait in ADHD and manifests across various developmental areas, including speech. Children and adolescents with ADHD often exhibit cluttering as a clinical symptom. It can be speculated that excessive talking may serve as a contributing factor to the development of cluttering. In this study, children and adolescents with ADHD were compared to those with TD in terms of cluttering symptoms. It was found that cluttering scores (including motor speech, language planning, attention, motor planning, and total scores) were higher in the ADHD subgroups than in TD individuals. Significant differences were observed between the inattentive type, combined type, and typical development groups ($P \leq$

.05) in motor speech, language planning, attention (such as not recognizing or responding to the listener's visual or verbal feedback), motor planning, and total scores. Issues in language planning were evident, including weak formulation, revisions, interjections, fillers, cohesion and coherence problems, poor grammar, impaired syntax, and irregular prosody and stress patterns. The ADHD group also showed higher levels of motor planning issues, impulsivity, and poor pragmatics than the TD control group, but there was no statistically significant difference in ADHD subtypes. In PCI-TR assessment, all scores were elevated and this difference was statistically significant ($P \leq .05$). While most literature focuses on stuttering, there is little conclusive data on cluttering. This study highlights the presence of cluttering features in children and adolescents with ADHD.

Cluttering is typically considered a fluency disorder marked by symptoms such as poor speech intelligibility, a fast or irregular speaking rate, inappropriate prosody, and disfluencies. It was concluded that speech and language development is impacted in children and adolescents with ADHD. In speech and language assessments, it was noted that the ADHD subgroups used shorter utterances in conversational tasks like initiation, maintenance, and termination, which may be linked to language planning. Cluttering was identified as a diagnostic criterion for these children and adolescents in a clinical setting.^{22,23} Attention-Deficit/Hyperactivity Disorder is also linked to cognitive processing delays, particularly in tasks that require sustained attention. Individuals may attempt to express their thoughts before fully organizing them, resulting in disordered speech. This can be seen in both children and adults who may have difficulty with the sequential flow of information in their speech.²⁴ The relationship between ADHD and cluttering can be understood through the lens of the disorder's core symptoms—impulsivity, hyperactivity, and attention deficits. These cognitive and behavioral characteristics lead to difficulties in regulating speech, which may result in fast-paced, disorganized, or disfluent verbal output. Both children and adults with ADHD may struggle with communication, impacting their social interactions and quality of life.

By understanding the cognitive and emotional underpinnings of ADHD, clinicians can better support individuals in managing both the behavioral and communicative challenges associated with the disorder. The finding that cluttering scores are higher in ADHD subgroups can be explained by several potential underlying mechanisms, related to both the cognitive and behavioral characteristics commonly associated with ADHD. These mechanisms involve attentional processes, executive functioning, and speech-language processing. Attention-Deficit/Hyperactivity Disorder is associated with deficits in executive functions, which include planning, organizing, working memory, and cognitive flexibility.⁴ Cluttering, which is characterized by rapid, disorganized, and often unintelligible speech,

is thought to be influenced by difficulties in the planning and regulation of speech production. People with ADHD may struggle with organizing their thoughts and speech in a coherent, structured manner, leading to more cluttered speech patterns. Research has shown that executive dysfunctions in ADHD can impair the ability to sequence and articulate ideas clearly, which may contribute to the increased cluttering scores observed in ADHD subgroups.²⁵

Individuals with ADHD frequently struggle with inattention, which can affect their ability to monitor and adjust their speech.¹⁷ This difficulty in self-monitoring can result in excessively fast speech with frequent fillers or unnecessary repetitions, which are hallmarks of cluttering. In ADHD, individuals may be less likely to notice these speech irregularities, leading to disorganized and unintelligible speech patterns that contribute to higher cluttering scores. In this study, the inattentive subgroup of ADHD-diagnosed children and adolescents exhibited more cluttering symptoms than their typically developed peers.

Attention-Deficit/Hyperactivity Disorder is also associated with motor coordination difficulties,¹⁷ which could impact the physical aspects of speech production. The coordination of fine motor movements required for speech articulation may be disrupted in ADHD, leading to more disorganized and rapid speech patterns that contribute to cluttering. Additionally, the impulsivity often observed in ADHD could lead to rushing through speech without adequately pausing or articulating words clearly, further contributing to the cluttering phenomenon. Cluttering in ADHD may also be related to the comorbidity between ADHD and other language disorders, such as developmental language disorder. Research suggests that individuals with ADHD often present with comorbid language disorders, including difficulties with speech fluency.²⁶ These language processing deficits may exacerbate the symptoms of cluttering in individuals with ADHD.

The higher cluttering scores observed in ADHD subgroups likely reflect a combination of cognitive and behavioral characteristics associated with the disorder, including executive dysfunction, inattention, poor speech monitoring, difficulties with temporal processing, and possible co-occurring language disorders. These factors can lead to disorganized and excessive speech patterns, contributing to the cluttering observed in ADHD individuals. Further research would be needed to explore the specific mechanisms linking ADHD and cluttering, but the evidence suggests that ADHD-related cognitive impairments likely play a significant role in the observed speech difficulties.^{1,27-29}

In summary, executive functions, such as attention, working memory, and cognitive flexibility, are vital for organizing and regulating speech. When these functions are impaired, individuals with cluttering struggle to plan and structure their speech effectively, leading to rapid and

disorganized verbal output. Impulsivity, which involves acting without thinking, also plays a role in cluttering. People with cluttering may speak impulsively, rushing through sentences or failing to monitor their speech, contributing to the rapid speech rate and errors typical of cluttering. Additionally, language processing deficits in cluttering involve difficulties in organizing linguistic information, which can result in fragmented and incoherent speech. These deficits affect the fluency and complexity of speech, making it difficult for individuals to produce clear, sequential speech. In sum, impairments in executive functions, impulsivity, and language processing contribute to the characteristic disorganized and rapid speech seen in cluttering.

Cluttering is distinct from other speech and language disorders such as stuttering, dysarthria, and general speech-language impairments due to its specific characteristics, including rapid, disorganized speech, lack of self-awareness, and its ties to cognitive and attentional deficits. In the context of ADHD, cluttering is accepted as a distinct condition because it is strongly linked to the attentional and executive functioning impairments typical of ADHD. The rapid and disorganized speech patterns observed in ADHD individuals are thought to result from impulsivity and difficulty in self-monitoring, which are hallmark features of cluttering.^{1,30-35} Cluttering was less common in older children, with 12% of the samples judged as cluttered, mostly in younger ages. While cluttering sometimes transitioned into stuttering in a minority of cases, the majority showed no significant differences between cluttering and recovered stuttering. Cluttering appeared to resemble recovered stuttering more than persistent stuttering, as seen in SSI-3 (Stuttering Severity Inventory-3) scores and secondary behaviors. Aetiological factors such as central nervous system issues, processing problems, and family history did not differ between the groups, suggesting that cluttering may not be distinct from stuttering. Overall, the findings support the idea that cluttering and stuttering share similarities, particularly with recovered forms of stuttering³⁶ and also additional more detailed testing of participants who clutter is necessary to explore the connection between cluttering and stuttering and to differentiate between the 2 perspectives discussed earlier. Ideally, individuals who solely experience cluttering should be identified, and assessments should be conducted at younger ages (i.e., under 8), similar to studies done with children who stutter.³⁷ In this study, the age of participants was younger, as the median age was approximately 9 years old approximately similar and but cluttering was seen more in the ADHD groups.

In cluttering, speech production difficulties can be understood through a neurocognitive model, which focuses on how cognitive, motor, and neural systems work together to produce fluent speech. The neurocognitive approach

suggests that cluttering results from disruptions in these interconnected systems, especially in the areas that govern motor control and language processing. Individuals who clutter often display irregular speech patterns, such as rapid articulation, poor sentence structure, and frequent normal disfluencies. These issues are thought to arise from difficulties in coordinating motor functions and cognitive processes required for speech planning. The basal ganglia, a brain structure involved in motor control and planning, and the cerebellum, which is crucial for speech timing and rhythm, are particularly important in this model. Research has shown that dysfunctions in these regions can lead to the speech irregularities characteristic of cluttering.³⁸

There is a basal ganglia dysfunction in cluttering involving speech-motor control and cognitive regulation. The basal ganglia play a key role in regulating the timing and rhythm of speech, which is essential for smooth and organized communication.³⁴ When there is dysfunction in the basal ganglia, this can result in speech that is too fast, disorganized, or difficult to follow, as seen in cluttering. The disruption in motor control can lead to rapid, poorly organized speech, as individuals with cluttering tend to omit syllables or words and often speak at a pace that is too fast for clarity.⁷ In ADHD cases, excessive speech can also affect speech rate and fluency, resulting in higher cluttering scores compared to TD peers in this study.

There is also basal ganglia dysfunction in ADHD. The basal ganglia are involved in regulating motor behavior, and their dysfunction is often associated with the motor symptoms of ADHD, such as hyperactivity. The basal ganglia help modulate attention and cognitive control. Research suggests that dysfunction in the basal ganglia circuitry, particularly the striatum, can contribute to the attentional and behavioral deficits characteristic of ADHD (Durstun et al., 2003).³⁵ Impulsivity is a core symptom of ADHD, and studies indicate that dysfunctions in the basal ganglia's role in regulating inhibitory control may contribute to this symptom. Impairments in the fronto-striatal circuits, which involve the basal ganglia, are thought to play a central role in the difficulty individuals with ADHD have in controlling impulsive behaviors.³⁶ The involvement of the basal ganglia was observed in both ADHD and cluttering, indicating a need for further research to investigate the potential shared relationship.

Limitations

There are some limitations to this study. The findings of this study are limited to the study population. In language assessment, the lack of qualitative assessment is another limitation of this study. Additionally, potential gender differences in ADHD, the underestimation of severity levels, and the absence of longitudinal data were other factors to consider. It is suggested that further research be conducted with groups having different demographic

characteristics and with a larger sample size, as well as the use of alternative tools like qualitative assessments and the examination of the effect of drugs on cluttering.

The research data is statistically large and sufficient, which emphasizes the findings' importance in determining the relationship between ADHD and cluttering.

These findings suggest that the nature of cluttering is distinct from other comorbid speech and language disorders associated with ADHD. This study concludes that cluttering is a commonly observed language and speech disorder in individuals with ADHD. It is recommended that all children diagnosed with ADHD undergo a more comprehensive evaluation of their language and speech abilities.

Data Availability Statement: The data that support the findings of this study are available upon request from the corresponding author.

Ethics Committee Approval: This study was approved by the Ethics Committee of Anadolu University (Approval no.: 503518; Date: 03.29.2023).

Informed Consent: Informed consent was obtained from the patients and parents of the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - S.T.F., M.N.S.; Design - S.T.F., M.N.S.; Supervision - S.T.F., M.N.S.; Resources - S.T.F., M.N.S.; Materials - M.N.S., S.T.F.; Data Collection and/or Processing - M.N.S., S.T.F.; Analysis and/or Interpretation - S.T.F., M.N.S.; Literature Search - S.T.F., M.N.S.; Writing - S.T.F., M.N.S.; Critical Review - S.T.F., M.N.S.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

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