The impact of Attention-Deficit/Hyperactivity Disorder and comorbid anxiety disorder on neuropsychological test performance: A retrospective clinical sample study

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SUMMARY

Objective: Attention-Deficit/Hyperactivity Disorder (ADHD) is characterized by executive dysfunction, particularly in working memory, inhibitory control, and attention. Anxiety disorders frequently co-occur with ADHD and may exacerbate or obscure these deficits. This study aimed to retrospectively evaluate neuropsychological test performance in ADHD with and without comorbid anxiety.

Method: This retrospective, cross-sectional study was conducted at the Child and Adolescent Psychiatry Outpatient Clinic of Kartal Dr Lutfi Kirdar City Hospital. Clinical records of patients aged 6–18 years presenting with inattention between January 2023 and April 2024 were reviewed. Performance on the Stroop Color–Word Test, d2 Test of Attention, Digit Span, and Porteus Maze Test was analyzed. Participants were categorized into six groups based on DSM-5 diagnoses: ADHD, ADHD + anxiety, ADHD + other diagnoses, anxiety only, other psychiatric diagnoses, and non-diagnosed.

Results: A total of 159 participants (53.5% male; mean age = 14.07±2.42 years) were included. Digit Span scores were significantly higher in the non-diagnosed group compared with all diagnostic groups ($p<0.01$). d2 error rates were highest in the ADHD group ($p<0.01$). Stroop 4, Stroop 5, and total completion times were significantly longer in the ADHD and ADHD + anxiety groups ($p<0.01$). Stroop correction scores were elevated in ADHD groups.

Discussion: Findings confirmed impairments in working memory, selective attention, and processing speed in ADHD and comorbid groups. Anxiety did not exert a protective effect on inhibitory control but appeared to impose additional burden on working memory. These results underscore the importance of considering anxiety when assessing executive dysfunction in ADHD.

Key Words: ADHD, anxiety disorder, neuropsychological tests, working memory, Stroop, d2 attention

INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (ADHD) is a prevalent neurodevelopmental disorder affecting approximately 5% of children and is associated with persistent, long-term adverse effects on academic achievement, social relationships, and overall adaptive functioning (1,2). Executive dysfunction has been consistently identified as a hallmark feature of ADHD by empirical studies and meta-analyses, with moderate impairments documented in inhibitory control, working memory, and cognitive flexibility (3,4). These deficits exert a significant impact on functional outcomes and account for much of the heterogeneity that characterizes the clinical presentation of ADHD.

Anxiety disorders represent one of the most common comorbidities in ADHD. Current epidemiological and clinical studies report that between approximately one-third and nearly half of children with ADHD either meet the diagnostic criteria for at least one anxiety disorder or exhibit clinically significant anxiety symptoms (5,6,7,8). However, the impact of anxiety on executive functions in ADHD is theoretically complex, and empirical findings remain inconsistent (9,10,11). These inconsistencies are attributed to several factors, including

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methodological differences in the measurement of working memory and inhibition (e.g., scales and neuropsychological tests), the manner in which anxiety is assessed (dimensional / trait measures), the failure to control for concurrent ADHD symptoms and other comorbidities, and the confounding of adult and pediatric samples (12).

Some of these studies propose that anxiety exacerbates deficits in attentional control and working memory within ADHD by increasing cognitive load and impairing processing efficiency (13,14,15,16). Conversely, other findings suggest that anxiety may transiently enhance inhibitory performance through arousal-based mechanisms, potentially leading to performance gains under specific conditions (17,18). Furthermore, a recent study indicated that trait anxiety is generally not associated with executive function impairments in children with ADHD. Consequently, comorbid anxiety may alleviate certain executive dysfunctions while exacerbating others, resulting in a multidimensional cognitive profile that differs from the isolated presentation of either disorder (12,19,20). These divergent results underscore the need for a more nuanced investigation into how anxiety modulates executive functioning within diagnostically heterogeneous pediatric samples.

Despite the extensive literature examining executive function in ADHD, a significant research gap persists regarding how neuropsychological tests commonly used in real-world clinical settings differentiate between ADHD, ADHD with comorbid anxiety, and isolated anxiety disorders. Most existing studies rely on highly controlled research samples, which often possess limited ecological validity. In contrast, outpatient child and adolescent psychiatry clinics frequently evaluate children with overlapping symptoms, varying levels of functional impairment, and complex patterns of comorbidity. Determining whether these diagnostic groups exhibit distinct performance patterns in routine neuropsychological assessments is of critical importance for the accurate interpretation of test results and for guiding clinical decision-making processes.

The present study addresses this research gap by examining the performance of children presenting with complaints of inattention on neuropsychological measures routinely administered in an outpatient clinical setting. By comparing groups diagnosed with ADHD, ADHD with comorbid anxiety, and anxiety disorders, we aimed to elucidate how these conditions reflect differentiated profiles of executive function and attentional performance within an ecologically valid, naturalistic clinical sample.

The hypotheses of our study are as follows:

1. Children diagnosed with ADHD are expected to demonstrate significantly more pronounced impairments in working memory and inhibitory control compared to those diagnosed with isolated anxiety disorders.

2. Children with ADHD + anxiety comorbidity are predicted to exhibit relatively superior inhibitory control compared to those with ADHD only.

3. The ADHD + anxiety group is expected to show more severe working memory impairments relative to the ADHD-only group.

4. Children with isolated anxiety disorders are expected to display relatively preserved executive function performance in comparison to both ADHD groups.

METHOD

This retrospective, cross-sectional study was conducted at the Child and Adolescent Psychiatry Outpatient Clinic of Kartal Dr Lutfi Kirdar City Hospital. Records of neuropsychological assessments routinely administered to patients presenting with complaints of inattention were obtained from electronic health records and archived files within the specified period (01 January 2023–01 April 2024). Ethical approval was obtained from the Institutional Non-Interventional Clinical Research Ethics Committee of Kartal Dr Lutfi Kirdar City Hospital (Decision No: 010.99/39). The study was carried out in accordance with the principles outlined in the Declaration of Helsinki.

Sample and Grouping

Inclusion criteria were as follows:

1. Age between 6 and 18 years;

2. Presentation to the outpatient clinic with complaints of inattention and/or a provisional diagnosis of ADHD;

3. Attainment of valid scores on at least two neuropsychological assessments (Stroop, d2, Porteus, Digit Span) within the same evaluation period;

4. Clinical assessment conducted in accordance with Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria.

Exclusion criteria included:

1. Presence of intellectual disability (Intelligence Quotient (IQ) < 70);

2. Neurological disorders, epilepsy, or chronic medical conditions;

3. Diagnosis of autism spectrum disorder;

4. İncomplete or insufficient neuropsychological test records.

Participants were categorized into six groups based on clinical evaluations conducted according to DSM-5 diagnostic criteria: ADHD, ADHD with comorbide anxiety disorder, ADHD with other psychiatric diagnoses, anxiety disorders, other psychiatric disorders, and a non-diagnosed group.

The "non-diagnosed group" consisted of individuals who presented with complaints of inattention but did not meet criteria for any psychiatric disorder according to DSM-5 following clinical assessment. We emphasize that the non-diagnosed group in this study does not represent a community-based healthy control sample. Thus, this group should not be interpreted as a true healthy control group; rather, it reflects a "clinically referred, non-diagnosed" comparison group. Although not a healthy control sample, this group was used as the reference category for comparative analyses within the study.

All neuropsychological assessments were conducted prior to the initiation of any pharmacological treatment. In our clinical protocol, medication is introduced only after neuropsychological testing is completed; therefore, none of the participants were using psychotropic medication at the time of assessment.

The Stroop Color-Word Test (SCWT): SCWT, originally developed by John Stroop in 1935, is sensitive to frontal lobe functioning. It assesses the ability to inhibit cognitive interference, which occurs when the processing of one attribute of a stimulus disrupts the simultaneous processing of another attribute. In addition to interference control, the test is used to evaluate other cognitive processes, including selective attention, processing speed, cognitive flexibility, and working memory. Longer completion times and increased error rates indicate difficulties in inhibitory control (21,22).

The test comprises four cards presented in five different conditions. During the first two cards, participants are instructed to read words, whereas in the third, fourth, and fifth cards, they are asked to name colors. Both completion time and the number of errors/corrections are recorded. Scoring is conducted in three ways: total errors, total corrections, and the time elapsed from the "start" command to the reading of the last stimulus (23).

d2 Test of Attention: The d2 Test of Attention, developed by Rolf Brickenkamp, is a paper-and-pencil measure designed to assess selective attention, concentration, and processing speed. Participants are required to accurately and rapidly identify target symbols among distractors. The test consists of 14 rows, each containing 47 characters. For each row, participants are given 20 seconds to cross out all instances of the "d" with two marks. Missed targets are recorded as Error 1 (E1), while incorrectly marked characters are recorded as Error 2 (E2). The sum of E1 and E2, divided by the

total number of processed items and multiplied by 100, yields the error percentage, which was used as the primary outcome measure in the present study. Error percentage was calculated based on raw performance data, and no age-normed or education-adjusted standardization was applied, as the primary aim of the study was to compare relative attentional accuracy across diagnostic groups rather than to determine performance relative to normative reference samples. Error percentage represents an established outcome parameter in the d2 literature and is commonly used as an index of accuracy-based selective attention and inhibitory control independent of processing speed (24).

The d2 Test has been shown to measure selective attention and concentration with high reliability (25).

Digit Span Subtest (WISC-IV): The Digit Span subtest is part of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV), one of the updated versions of the Wechsler scales developed to assess the cognitive abilities of children aged 6 to 16 years (26). In recent years, the WISC-IV has been standardized in Türkiye, and this updated form has been widely implemented in clinical and research settings (27).

In the present study, the Digit Span subtest of the WISC-IV was employed to evaluate short-term memory and verbal working memory. The forward digit span primarily measures short-term memory capacity, whereas the backward digit span is more sensitive to executive functioning and information manipulation processes (28).

In the present study, Digit Span was analyzed as a single composite score. This methodological decision was necessitated by the wide age range of the sample and the use of age-adjusted WISC-IV scaled scores. According to the WISC-IV standardization, reliable and comparable scaled scores are provided for the total Digit Span score across different age groups; however, age-adjusted scaled scores for the forward and backward components separately are not consistently available. Accordingly, all analyses were conducted using age-adjusted WISC-IV scaled scores rather than raw scores (28,29).

Porteus Maze Test: The Porteus Maze Test, originally developed by Porteus and later adapted into Turkish by Toğrol, is a non-verbal assessment tool requiring participants to complete progressively complex mazes without lifting the pencil or crossing the lines (30). The test is designed to evaluate executive functioning, planning ability, visuospatial skills, and adaptability to novel situations (31).

Statistical Analysis

Statistical analyses were conducted using NCSS (Number Cruncher Statistical System) 2020 Statistical Software (NCSS LLC, Kaysville, Utah, USA). In evaluating the study data, quantitative variables were summarized using descriptive statistics (mean, standard deviation, median, minimum, and maximum), while qualitative variables were presented as frequencies and percentages. Normality of distribution was assessed through skewness–kurtosis values and Box Plot visual inspection.

For comparisons of executive function scores across diagnostic groups, sex, age, and grade level were entered as covariates (adjusted), and ANCOVA was applied. When significant main effects were detected, Bonferroni-adjusted post-hoc tests were used to determine the source of group differences. In addition, the assumption of homogeneity of regression slopes was evaluated by testing interaction terms between diagnostic group and each covariate (age, sex, and grade level). None of the interaction terms were statistically significant (all $p > .05$), indicating that the assumption was met for all ANCOVA models.

Results were evaluated within a 95% confidence interval, with statistical significance set at $p < .05$.

Interpretation of Partial Eta Squared (32):

0.01-0.05	Small effect size
0.06-0.14	Medium effect size
≥0.14	Large effect size

Table 1. Distribution of descriptive characteristics

		n (%)
Gender	Male	85 (53.5)
	Female	74 (46.5)
Age	*Mean – SD*	14.07–2.42
	Median (Min□Max)	14.2 (6.5-17.9)
Education Level	Primary school	13 (8.2)
	Middle school	51 (32.1)
	High school	95 (59.7)
Diagnosis	Clinically referred, non-diagnosed group	16 (10.1)
	ADHD	62 (39.0)
	ADHD +Anxiety	18 (11.3)
	ADHD +Other psychiatric disorders	35 (22.0)
	Anxiety disorders	17 (10.7)
	Other psychiatric disorders	11 (6.9)

Note. The clinically referred, non-diagnosed group does not represent a healthy control sample; participants in this group were clinically evaluated for attentional complaints but did not meet criteria for a psychiatric diagnosis.

Cohen proposed these benchmarks for eta squared (η^2). Partial eta squared (η^2p) values are commonly interpreted using the same criteria, as emphasized by Richardson (2011), who states: "Partial eta squared values are commonly interpreted using Cohen's benchmarks for η^2" (32,33).

RESULTS

The study was conducted with a total of 159 participants, of whom 46.5% (n = 74) were female. Participants' ages ranged from 6.5 to 17.9 years, with a mean age of 14.07 ± 2.42 years. The descriptive characteristics of the participants are presented in Table 1.

In the ADHD + Other Diagnoses group, comorbid conditions accompanying ADHD included oppositional defiant disorder in 8.8%, depression in 4.4%, learning disorder in 2.5%, conduct disorder in 1.9%, tic disorder in 1.3%, obsessive compulsive disorder in 1.3%, trichotillomania in 0.6%, primary nocturnal enuresis in 0.6%, and encopresis in 0.6% of the total sample. In the Other Psychiatric Disorders group, diagnoses consisted of depression in 2.5%, obsessive–compulsive disorder in 1.3%, conduct disorder in 1.3%, adjustment disorder in 1.3%, and eating disorder in 0.6% of the total sample.

The mean and median scores of the psychometric assessments administered to the participants are presented in Table 2.

Comparisons of psychometric test performance across diagnostic groups are presented in Table 3. When age, sex, and grade level were controlled as covariates, no significant differences were observed for the Porteus Maze Test ($F(5, 153) = 1.81$, $p = 0.367$, partial $\eta^2 = 0.037$).

When age, sex, and grade level were controlled as covariates, Digit Span scores differed significantly across diagnostic groups. ANCOVA revealed a significant main effect of diagnostic group on Digit Span performance ($F (5, 153) = 32.95$, $p = 0.001$, partial $\eta^2 = 0.534$). The clinically referred, non-diagnosed group had significantly higher Digit Span scores compared with the ADHD, ADHD +anxiety, ADHD +other diagnoses, anxiety disorders, and other psychiatric disorders groups (respectively: $p = 0.001$; $p = 0.001$; $p = 0.001$; $p = 0.001$; $p = 0.001$; $p < 0.01$). Additionally, participants in the "other psychiatric disorders" group scored higher than those in the ADHD group ($p = 0.010$; $p < 0.05$). The effect size was calculated as 0.663.

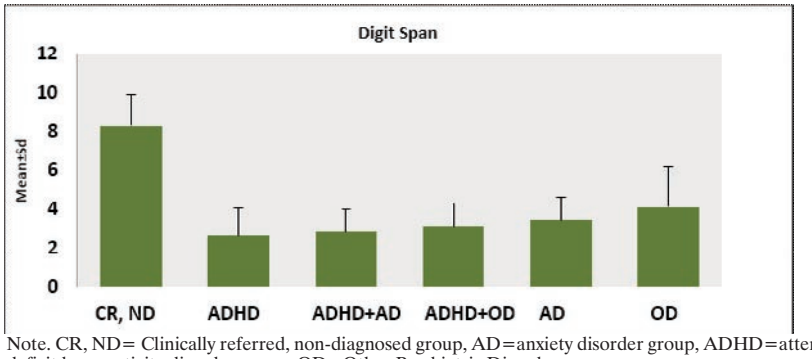
The distribution of Digit Span scores across diagnostic groups is illustrated in Figure 1.

Table 2. Distribution of scores on psychometric tests

Measure	*Mean ± SD*	Median (Min-Max)
The Porteus Maze Test	94.75±14.48	96 (43-127)
Digit Span	3.52±2.15	3 (1-10)
d2 Test of Attention (error percentage)	11.29±7.22	10.2 (0.3-40)
Stroop 1 time	9.56±2.41	9 (6-20)
Stroop 2 time	10.80±3.76	10 (6-33)
Stroop 3 time	14.80±4.58	14 (7-35)
Stroop 4 time	19.56±5.67	19 (10-47)
Stroop 4 errors	0.06±0.40	0 (0-4)
Stroop 4 corrections	0.40±0.76	0 (0-5)
Stroop 5 time	29.99±10.22	28 (14-84)
Stroop 5 errors	0.63±2.27	0 (0-18)
Stroop 5 corrections	1.45±1.50	1 (0-7)
Total Stroop time	84.71±21.91	80 (46-204)

Note. Time values are presented in seconds. Digit Span values represent age-adjusted WISC-IV scaled scores. Although the theoretical scaled score range is 1-19, the observed range in the present sample was 1-10.

Figure 1. Distribution of Digit Span scores across diagnostic groups



Note. CR, ND= Clinically referred, non-diagnosed group, AD=anxiety disorder group, ADHD=attention deficit hyperactivity disorder group, OD=Other Psychiatric Disorder group

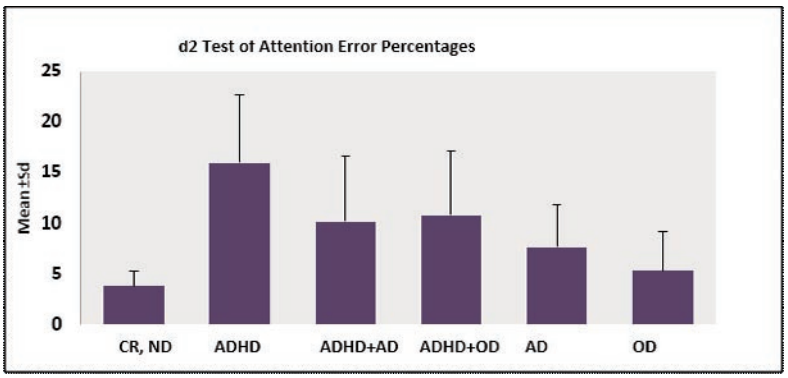
ANCOVA revealed a significant main effect of diagnostic group on d2 Test of Attention error percentages after adjusting for age, sex, and grade level ($F(5, 153) = 12.42$, $p = 0.001$, partial $\eta^2 = 0.301$). The clinically referred, non-diagnosed group demonstrated lower error percentages compared to participants with ADHD, ADHD with comorbid anxiety, and ADHD with other psychiatric diagnoses ($p = 0.001$, $p = 0.022$, and $p = 0.001$, respectively; $p < 0.05$). Conversely, individuals diagnosed with ADHD exhibited higher error percentages relative to those with ADHD + anxiety, ADHD + other psychiatric diagnoses, anxiety disorders, and other psychiatric disorders ($p = 0.019$, $p = 0.006$, $p = 0.001$, and $p = 0.001$, respectively; $p < 0.01$). The distribution of d2 Test of Attention error percentages across diagnostic groups is illustrated in Figure 2.

Comparisons of Stroop Test Card 4 scores across diagnostic groups are presented in Table 4. After adjusting for age, sex, and grade level, Stroop Test Card 4 completion times differed significantly across diagnostic groups ($F(5, 153) = 3.49$, $p = 0.005$, partial $\eta^2 = 0.108$). The clinically referred, non-diagnosed group demonstrated shorter Stroop 4 times compared with the ADHD +anxiety and ADHD +other groups ($p = 0.004$; $p = 0.012$; $p < 0.05$). Similarly, individuals in the "other psychiatric disorders" group had shorter Stroop 4 times than those in the ADHD +anxiety and ADHD +other groups ($p = 0.007$; $p = 0.021$; $p < 0.05$). The effect size was calculated as 0.160.

When age, sex, and grade level were controlled as covariates, Stroop 4 correction scores did not differ significantly across diagnostic groups ($p > 0.05$).

Comparisons of Stroop Test Card 5 scores across diagnostic groups are presented in Table 5. Stroop Test Card 5 completion times showed significant differences across diagnostic groups after covariate adjustment ($F(5, 153) = 3.22$, $p = 0.009$, partial $\eta^2 = 0.100$). Participants in the clinically referred, non-diagnosed group had shorter Stroop 5 times compared with those in the ADHD and ADHD +other groups ($p = 0.002$ and $p = 0.001$, respectively; $p < 0.01$). The effect size was calculated as 0.130. When age, sex, and grade level were controlled as covariates, Stroop 5 correction scores showed statistically significant differences across diagnostic groups ($p=0.001$; $p< 0.01$). Participants

Figure 2. Distribution of d2 Test of Attention error percentages across diagnostic groups



Note. CR, ND= Clinically referred, non-diagnosed group, AD=anxiety disorder group, ADHD=attention deficit hyperactivity disorder group, OD=Other Psychiatric Disorder group

Table 3. Comparison of psychometric test scores across diagnostic groups

	F	Df	p	Partial Eta Squared	Model F	Model p	R^2
The porteus maze test							
Gender	208,930	1	*0,303*	0,007			
Age	39,746	1	*0,653*	0,001			
Education Level	49,125	1	*0,617*	0,002	1,814	*0,052*	0,150
Diagnosis	153,463	5	*0,563*	0,027			
		Mean ± SD	*p*	Partial eta squared			
[1]Clinically referred, non-diagnosed group (n=16)		98,35±3,55					
[2]ADHD (n=62)		93,53±1,86					
[3]ADHD+anxiety (n=18)		91,62±3,84					
[4]ADHD+other psychiatric disorders (n=35)		93,76±2,40	*0,367*	0,037			
[5]Anxiety disorders (n=17)		91,20±4,50					
[6] Other psychiatric disorders (n=11)		102,11±4,53					
Digit Span	F	Df	p	Partial Eta squared			
Gender	0,034	1	*0,853*	0,000			
Age	1,585	1	*0,210*	0,011	22,441	*0,001***	0,686
Education Level	0,001	1	*0,982*	0,000			
Diagnosis	32,948	5	*0,001***	0,534			
		Mean±Sd	*p*	Partial Eta Squared			
[1]Clinically referred, non-diagnosed group (n=16)		8,45±0,32					
[2]ADHD (n=62)		2,51±0,17					
[3]ADHD+anxiety (n=18)		3,33±0,35					
[4]ADHD+other psychiatric disorders (n=35)		3,02±0,22	*0,001***	0,663			
[5]Anxiety disorders (n=17)		3,54±0,41					
[6] Other psychiatric disorders (n=11)		4,05±0,41					
d2 Test of Attention (error percentage)	F	Df	p	Partial Eta Squared			
Gender	0,021	1	*0,884*	0,000			
Age	0,846	1	*0,359*	0,006	6,546	*0,001***	0,389
Education Level	1,132	1	*0,289*	0,008			
Diagnosis	12,422	5	*0,001***	0,301			
		Mean ± SD	*p*	Partial Eta Squared			
[1]Clinically referred, non-diagnosed group (n=16)		3,74±1,50					
[2]ADHD (n=62)		15,70±0,79					
[3]ADHD+anxiety (n=18)		11,14±1,62					
[4]ADHD+other psychiatric disorders (n=35)		10,72±1,02	*0,001***	0,343			
[5]Anxiety disorders (n=17)		6,84±1,90					
[6] Other psychiatric disorders (n=11)		4,84±1,92					

Note. Analyses were conducted using ANCOVA adjusted for age, sex, and grade level. Post hoc comparisons were performed using Bonferroni correction. The clinically referred, non-diagnosed group does not represent a healthy control sample ***p<0.01*

in the clinically referred, non-diagnosed group had lower Stroop 5 correction scores compared with those in the ADHD group ($p = 0.004$; $p < 0.01$). The effect size was calculated as 0.102.

Comparisons of total Stroop test completion times across diagnostic groups are presented in Table 6. Total Stroop test completion times differed significantly across diagnostic groups after adjusting for age, sex, and grade level ($F(5, 153) = 2.42$, $p = 0.039$, partial $\eta^2 = 0.078$). Participants in the clinically referred, non-diagnosed group had shorter total Stroop completion times compared with those in the ADHD, ADHD +anxiety, and ADHD +other groups ($p = 0.001$; $p = 0.043$; $p = 0.007$; $p < 0.05$). The effect size was calculated as 0.115.

DISCUSSION

In the present study, we retrospectively evaluated the results of routinely administered neuropsychological tests (Stroop, d2, Digit Span, and Porteus

Maze) in children and adolescents presenting with complaints of inattention, with the aim of comparing executive function and attentional profiles across different diagnostic groups. Before interpreting the group differences observed in this study, an important methodological consideration should be emphasized. The clinically referred, non-diagnosed group did not constitute a healthy control sample drawn from the general population, but rather a clinically referred group evaluated for attentional complaints who did not meet criteria for a psychiatric diagnosis. As such, group comparisons should be interpreted within the context of a realworld clinical referral setting rather than as contrasts between psychopathology and normative development. This distinction is critical for understanding both the magnitude and the clinical meaning of the observed executive function differences. In interpreting these findings, it is important to consider that effect size estimates particularly for Digit Span may be influenced by the unequal distribution of participants across diagnostic groups. The clinically referred, non-diagnosed group was relatively small, and this imbalance may have contributed to inflated partial eta squared values. Accordingly, these large effect sizes should be interpreted conservatively, as reflecting potentially meaningful patterns within a realworld clinical referral sample rather than precise estimates of population level effects. In addition to group size imbalance, several methodological factors may have contributed to the relatively large partial eta squared values observed in the present study, particularly for Digit Span performance. Restricted variance within certain diagnostic groups may have accentuated between-group differences, thereby inflating effect size estimates. Moreover, the use of age-adjusted scaled scores within a clinically referred sample may introduce a degree of metric compression, which can further amplify apparent group effects. Finally, although ceiling or floor effects were not formally tested, the possibility that some measures exhibited limited score dispersion in specific groups cannot be excluded. Accordingly, the reported effect sizes should be interpreted with appropriate caution and within the methodological

Table 4. Comparison of Stroop Test Card 4 Scores Across Diagnostic Groups

	F	df	p	Partial Eta Squared	Model F	Model p	R^2
Stroop 4 time							
Gender	0,237	1	*0,627*	0,002			
Age	0,768	1	*0,382*	0,005	4,059	*0,001***	0,238
Education Level	3,402	1	*0,067*	0,023			
Diagnosis	3,487	5	*0,005***	0,108			
		Mean ± SD	*p*	Partial eta squared			
[1]Clinically referred, non-diagnosed group (n=16)		15,94±1,28					
[2]ADHD (n=62)		19,81±0,67					
[3]ADHD+anxiety (n=18)		22,90±1,38					
[4]ADHD+other psychiatric disorders (n=35)		21,20±0,86	*0,001***	0,160			
[5]Anxiety disorders (n=17)		17,02±1,62					
[6] Other psychiatric disorders (n=11)		15,20±1,63					
Stroop 4 corrections	F	df	p	Partial Eta Squared			
Gender	1,280	1	*0,260*	0,009			
Age	1,095	1	*0,297*	0,008	0,594	*0,867*	0,055
Education Level	1,076	1	*0,301*	0,007			
Diagnosis	0,733	5	*0,600*	0,025			
		Mean – SD	*p*	Partial Eta Squared			
[1]Clinically referred, non-diagnosed group (n=16)		0,28±0,20					
[2]ADHD (n=62)		0,48±0,10					
[3]ADHD+anxiety (n=18)		0,25±0,21					
[4]ADHD+other psychiatric disorders (n=35)		0,48±0,13	*0,570*	0,026			
[5]Anxiety disorders (n=17)		0,07±0,25					
[6] Other psychiatric disorders (n=11)		0,56±0,25					

Note. Analyses were conducted using ANCOVA adjusted for age, sex, and grade level. Post hoc comparisons were performed using Bonferroni correction. ***p<0.01*

context of a heterogeneous, real-world clinical referral sample rather than as precise estimates of population-level effects. Such methodological factors have been previously noted in the statistical literature as potential influences on effect size estimation (32, 34).

Our findings can be tentatively summarized along three main axes. First, short-term memory and working memory performance, as measured by the Digit Span task, was significantly higher in the clinically referred, non-diagnosed group. Second, in the domain of selective attention and processing speed, indexed by d2 error percentages, the most pronounced impairments were observed in the ADHD group. Marked deficits were also evident in the ADHD + anxiety and ADHD + other diagnosis groups. Third, indices of inhibitory control, interference suppression, and processing speed, reflected by Stroop 4, Stroop 5, and total completion times, were significantly longer in the ADHD, ADHD + anxiety, and ADHD + other groups. By contrast, scores on the Porteus Maze Test did not differ significantly among diagnostic groups.

The literature consistently emphasizes that individuals with ADHD exhibit core deficits in executive functions, particularly in working memory and attentional processes, which are considered hallmark features of the disorder. Our findings are broadly consistent with this evidence (3, 35, 36). The significantly lower Digit Span scores observed in the ADHD group compared with the clinically referred, non-diagnosed group provide additional support for the presence of deficits in verbal working memory and short-term memory among individuals with ADHD (37, 38). Similarly, our observation that d2 Test of Attention error percentages were highest in the ADHD group and lowest in the clinically referred, non-diagnosed group mirrors prior findings in the literature, highlighting substantial impairments in selective attention and error sensitivity in ADHD (39,40).

The findings of our study regarding comorbid anxiety disorder revealed a pattern that diverges

Table 5. Comparison of Stroop Test Card 5 scores Across Diagnostic Groups

	F	df	p	Partial Eta Squared	Model F	Model p	R^2
Stroop 5 time							
Gender	0,532	1	*0,467*	0,004			
Age	2,003	1	*0,159*	0,014	2,682	*0,002***	0,207
Education Level	3,847	1	*0,052*	0,026			
Diagnosis	3,215	5	*0,009***	0,100			
		Mean – SD	*p*	Partial eta squared			
[1]Clinically referred, non-diagnosed group (n=16)		20,74–2,42					
[2]ADHD (n=62)		31,34–1,27					
[3]ADHD+anxiety (n=18)		31,01–2,62					
[4]ADHD+other psychiatric disorders (n=35)		32,47–1,64	*0,001***	0,130			
[5]Anxiety disorders (n=17)		28,70–3,07					
[6] Other psychiatric disorders (n=11)		24,69–3,09					
Stroop 5 corrections	F	df	p	Partial Eta Squared			
Gender	0,077		*0,782*	0,001			
Age	0,012		*0,914*	0,000	1,433	*0,145*	0,122
Education Level	0,038		*0,846*	0,000			
Diagnosis	2,225		*0,055*	0,072			
		Mean – SD	*p*	Partial Eta Squared			
[1]Clinically referred, non-diagnosed group (n=16)		0,27–0,37					
[2]ADHD (n=62)		1,84–0,20					
[3]ADHD+anxiety (n=18)		1,71–0,40					
[4]ADHD+other psychiatric disorders (n=35)		1,57–0,25	*0,001***	0,102			
[5]Anxiety disorders (n=17)		0,83–0,47					
[6] Other psychiatric disorders (n=11)		1,39–0,48					

Note. Analyses were conducted using ANCOVA adjusted for age, sex, and grade level. Post hoc comparisons were performed using Bonferroni correction. ***p<0.01*

Table 6. Comparison of Total Stroop Test Completion Times Across Diagnostic Groups

	F	df	p	Partial Eta Squared	Model F	Model p	R^2
Stroop Total Time							
Gender	0,573		*0,450*	0,004			
Age	0,274		*0,602*	0,002			
Education Level	1,721		*0,192*	0,012	2,698	*0,002***	0,208
Diagnosis	2,420		*0,039**	0,078			
		Mean – SD	*p*	Partial eta squared			
[1]Clinically referred, non-diagnosed group (n=16)		68,60–5,18					
[2]ADHD (n=62)		87,79–2,72					
[3]ADHD+anxiety (n=18)		82,71–5,61					
[4]ADHD+other psychiatric disorders (n=35)		90,77–3,51	*0,003***	0,115			
[5]Anxiety disorders (n=17)		79,26–6,58					
[6]Other psychiatric disorders (n=11)		71,66–6,62					

Note. Analyses were conducted using ANCOVA adjusted for age, sex, and grade level. Post hoc comparisons were performed using Bonferroni correction. ***p<0.01*

somewhat from previous literature. On measures of inhibitory control and processing speed (Stroop completion times), the ADHD + anxiety group did not demonstrate superior performance compared with the ADHD-only group; instead, they exhibited similar or, in certain comparisons, even slower response times. This observation does not fully correspond with prior meta-analytic and observational findings suggesting that anxiety may attenuate inhibitory control deficits in ADHD, with relatively improved inhibitory performance reported in ADHD with comorbid anxiety.

Although the six-group structure was retained to preserve ecological validity and reflect real world clinical presentations, the relatively small size of some diagnostic subgroups and the multiple comparisons performed necessitate a cautious interpretive framework. Accordingly, the present findings should be viewed as exploratory and hypothesis generating rather than confirmatory, highlighting patterns that warrant replication in larger and more balanced samples. These findings can be interpreted within several complementary theoretical frameworks. First, executive function heterogeneity models emphasize that ADHD is not a unitary executive dysfunction but rather encompasses distinct cognitive domains, such as working memory, attention, and inhibition that follow partially dissociable patterns and developmental trajectories (35). Our results are broadly consistent with this framework, showing large effect sizes for Digit Span and d2 performance, moderate effects for Stroop completion times, and no discriminative effect for the Porteus Maze Test. This pattern suggests that comorbid anxiety may interact with certain executive domains while exerting minimal influence on others, imposing additional cognitive load rather than systematically improving inhibitory control.

From the perspective of the RDoC Cognitive Systems domain, the tasks employed in this study map onto core constructs including cognitive control and inhibition (Stroop), selective attention and processing speed (d2), and working memory (Digit Span). The observed performance patterns across ADHD, ADHD with comorbid anxiety, and anxiety-only groups support a dimensional and transdiagnostic interpretation within this clinically referred sample executive dysfunction. Rather than reflecting discrete diagnostic categories, these differences appear to index variability in underlying cognitive systems that cut across traditional diagnostic boundaries (41,42).

Attentional Control Theory (ACT) provides a coherent account of why comorbid anxiety did not confer enhanced inhibitory performance in the ADHD + anxiety group. According to ACT, anxiety disrupts processing efficiency by weakening goal-directed attentional control and increasing reliance on stimulus-driven or internally focused processes, such as worry (15, 43). Under neutral, non-emotional testing conditions, such as those characterizing the Stroop task in the present study, anxiety is unlikely to produce the heightened caution or performance-enhancing effects sometimes observed in evaluative or threat-related contexts. Instead, central executive resources may become increasingly taxed, resulting in prolonged response times despite preserved accuracy. This mechanism

plausibly explains why the ADHD + anxiety group exhibited longer Stroop completion times without corresponding increases in error rates (44).

Importantly, this pattern may also be attributable to the nature of the outcome measures employed. Executive functioning in the present study was predominantly indexed by time- and speed-based parameters. Although participants demonstrated comparable accuracy and correction scores across groups, time-dependent measures appeared to be more sensitive to the cognitive slowing and increased mental effort associated with anxiety (13,14,15). Moreover, the comorbid anxiety group was clinically heterogeneous, encompassing different anxiety disorder subtypes and varying levels of state anxiety. Such heterogeneity may further obscure any consistent masking or compensatory effects of anxiety on executive performance in clinically referred samples (45).

Finally, developmental considerations are essential for interpreting these findings. Inhibitory control tends to reach near adult levels earlier in development, whereas working memory and cognitive flexibility continue to mature throughout adolescence (46, 47). Age related convergence in inhibitory processes may therefore have reduced detectable differences between ADHD and ADHD + anxiety groups, while the more protracted developmental trajectories of working memory and attentional control remained sensitive to diagnostic variation. This interpretation aligns with developmental delay models of ADHD, which posit disrupted yet not necessarily deviant executive function maturation (48).

Together, these complementary theoretical frameworks underscore that comorbid anxiety does not exert a uniform or straightforward influence on executive functioning in ADHD. Rather, its effects appear to be domain-specific, developmentally contingent, and shaped by task characteristics, anxiety subtype, and underlying cognitive demands (36,47). This nuanced interaction carries important clinical implications, as understanding whether anxiety imposes additional burden, or alters the expression, of executive function deficits may refine both diagnostic interpretation and individualized intervention planning.

Consistent with this view, working memory impairments were evident in both the ADHD and ADHD + anxiety groups, with significantly lower Digit Span performance compared to the non-diagnosed group. This pattern aligns with theoretical and empirical models suggesting that anxiety imposes a sustained cognitive load that competes for limited executive resources, particularly within working memory systems (10, 49). Anxiety related cognitive activity may strain processing capacity, disrupt attentional focus, and complicate mental manipulation, thereby impairing short-term memory performance (15, 50).

Importantly, anxiety in the present study was assessed categorically through structured clinical interviews rather than via dimensional symptom measures. Accordingly, the “anxiety” captured here likely reflects trait-like, chronic anxiety rather than transient, state-dependent fluctuations. Tasks such as Digit Span, administered under neutral and non-evaluative conditions, are known to be more sensitive to enduring cognitive interference than to acute state anxiety. This may explain why the ADHD + anxiety group did not exhibit disproportionately greater working memory impairment relative to the ADHD-only group. This interpretation is consistent with Attentional Control Theory, which posits that state anxiety exerts stronger disruptive effects under conditions of evaluative threat, a context not present in the current clinical assessment setting (15, 43).

At the same time, prior studies have reported mixed findings, with some suggesting that anxiety may exaggerate estimates of working memory impairment in ADHD (20, 51), highlighting the complexity of this interaction. This heterogeneity was also reflected in the attentional findings of the present study. On the d2 Test of Attention, individuals with ADHD and comorbid anxiety demonstrated lower error rates compared with those with ADHD alone. This result mirrors inconsistencies in the literature and underscores the importance of considering anxiety subtypes and symptom dimensions, as different anxiety profiles may differentially influence attentional vigilance, error monitoring,

and cautious responding (14).

In contrast, inhibitory control and processing speed measures revealed a more consistent pattern across ADHD-based groups. Prolonged Stroop completion times were observed in the ADHD, ADHD + anxiety, and ADHD + other diagnosis groups, whereas error and correction rates did not differ significantly. This dissociation suggests that time-based indices may be more sensitive than accuracy metrics in capturing the cognitive slowing and increased executive load associated with anxiety. In line with Attentional Control Theory, anxiety may preserve performance effectiveness while reducing processing efficiency, leading to slower response times despite intact error control (44).

The absence of significant group differences on the Porteus Maze Test warrants specific consideration. Several methodological and conceptual factors may account for this finding. First, the task may have been insufficiently demanding across the wide developmental range of 6–18 years, resulting in restricted variability and potential ceiling effects. Second, contemporary executive function heterogeneity models emphasize that ADHD is most robustly associated with deficits in working memory, sustained attention, and interference control, while planning measures often show weaker and more inconsistent associations (3). Consistent with this framework, the present study demonstrated large effect sizes for Digit Span and d2 error percentage, moderate effects for Stroop latencies, but no discriminative effect for the Porteus Maze.

Finally, given the clinically heterogeneous and ecologically representative nature of the sample (52), it is plausible that the broad planning abilities assessed by the Porteus Maze were relatively preserved across diagnostic groups. In contrast, more narrowly defined executive processes, such as verbal working memory, selective attention, and interference control, yielded clearer diagnostic differentiation. Together, these findings suggest that the Porteus Maze Test may be less sensitive than Digit Span, d2, and Stroop measures for distinguishing ADHD and comorbid presentations within this developmental period.

From a clinical perspective, the present results suggest the practical utility of brief, routinely administered neuropsychological tools in real-world assessment settings. Digit Span and the d2 Test of Attention emerged as particularly sensitive measures for differentiating ADHD and comorbid diagnostic subgroups among patients presenting with attentional complaints. Stroop completion times, rather than error indices, provided additional insight into inhibitory control and processing speed inefficiencies, especially in the presence of comorbid anxiety. These findings further emphasize the importance of incorporating dimensional assessment of anxiety when interpreting executive function test performance, as comorbid anxiety may either obscure or exaggerate cognitive deficits depending on the domain assessed and the metrics employed.

Several limitations of this study should be acknowledged. Although children with an IQ below 70 were excluded, standardized IQ scores were not available for all participants, limiting control over more subtle differences in intellectual functioning. The Digit Span test was analyzed as a composite score due to the wide age range of the sample and reliance on age-adjusted WISC-IV norms; however, this approach may have reduced the specificity of inferences regarding distinct working memory subcomponents. Diagnostic groups were unbalanced in terms of sample size, which may have reduced statistical power for some comparisons, despite the use of covariate-adjusted ANCOVA models, conservative post-hoc corrections, and effect size reporting. The retrospective design of the study restricted the standardization of assessment conditions and precluded systematic evaluation of contextual factors such as sleep patterns or psychosocial stress. In addition, the absence of symptom severity measures prevented dimensional analyses of executive function in relation to symptom burden. Anxiety disorders were treated categorically without differentiation by subtype or severity, which may have reduced interpretive precision. Stroop 4 and 5 error scores showed extremely restricted variability, with near-ceiling performance across participants, leading to their exclusion from inferential analyses and suggesting that error-based Stroop indices may be less sensitive for differentiating diagnostic groups in this develop-

mental range. Finally, the restricted performance range observed on the Porteus Maze Test suggests limited sensitivity of this measure within the studied age group. Future prospective studies employing more balanced samples, dimensional symptom measures, and broader executive function batteries are warranted to extend and refine the present findings.

In conclusion, the present study suggests that brief and routinely administered neuropsychological measures, particularly Digit Span and the d2 Test of Attention, provide clinically meaningful and practical indicators for differentiating ADHD and comorbid diagnostic presentations in children and adolescents referred for attentional complaints. These tools may be useful for identifying impairments in working memory and selective attention within real world, time limited clinical settings. Across diagnostic groups, ADHD was characterized by robust deficits in working memory, selective attention, and processing efficiency, while prolonged response times on Stroop tasks indicated impairments in inhibitory control and cognitive speed in both ADHD and ADHD with anxiety. In contrast, the absence of group differences on the Porteus Maze Test suggests limited sensitivity of planning-based measures for diagnostic differentiation in this developmental range, highlighting the importance of task selection when evaluating executive functioning in clinical practice. At the same time, these findings should be interpreted within the context of a clinically referred and ecologically valid sample. The present results are best viewed as exploratory and hypothesis generating rather than confirmatory, particularly given the heterogeneity of diagnostic groups and the imbalance in subgroup sizes. Accordingly, replication in larger and more balanced samples is warranted to further establish the robustness and generalizability of these observations.

Importantly, our findings emphasize that comorbid anxiety does not uniformly enhance or attenuate executive functioning in ADHD. Rather, anxiety appears to exert domain-specific and sometimes counterbalancing effects, contributing to cognitive slowing and increased working memory load without conferring consistent benefits in inhibitory control. This underscores the necessity of considering comorbid anxiety, preferably through dimensional assessment, when interpreting executive function test performance in ADHD populations.

Overall, the results support the clinical utility of multi-indicator executive function assessment approaches and reinforce the value of ecologically valid data derived from routine clinical referrals. Future prospective studies incorporating standardized symptom severity measures, balanced diagnostic samples, and developmentally sensitive executive function tasks will be essential for refining diagnostic interpretation and informing individualized intervention strategies.

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