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Working Memory Load and Inhibition Performance Among Children With ADHD

Ibrahim Orhan[a,b]

Ishin Paralik[b]

[a]Department of Psychology, University of Gloucestershire, UK

[b]Department of Psychology, Bahçeşehir Cyprus University, Nicosia, TRNC

Corresponding author:

Ibrahim Orhan

Department of Psychology

University of Gloucestershire

Cheltenham, UK

GL50 2RH

Tel: +441242714700

Email: iorhan@glos.ac.uk

Abstract

Objective: Inhibition is a critical executive function for stopping routine responses and facilitating planned behaviour. Although the results are mixed, individuals with ADHD are reported to have poorer inhibition performance; however, this remains a subject of ongoing debate. Findings in the literature suggest that the central executive component of working memory and resource allocation could play a role. The present study investigated whether varying maintenance demands would influence inhibition performance among children with and without ADHD. **Materials and Methods:** The study sample comprised 80 children aged between 7 and 11 (60 males and 20 females; M_{age} = 9.01). For the first time in the literature, participants completed a Go/no-go Task with four levels of gradually increased working memory load. The data was analysed using mixed repeated measures ANOVA. **Results and Conclusion**: A significant main effect of group, load and interaction were obtained. There was no significant difference in inhibition performance between the two groups when there was no working memory load. However, in the presence of a load, the ADHD group consistently scored lower across all load conditions. Their inhibition performance declined as the load increased. Under the heaviest load condition, the ADHD group obtained the worst scores, whereas the control group's performance improved. In conclusion, introducing a working memory load has a large negative impact on the inhibition performance of the ADHD group but not the control group. These results suggest that children with ADHD struggle to allocate enough resources to meet the increased task demand for optimal inhibition performance.

Keywords: ADHD, inhibition performance, working memory load, resource allocation, concentration.

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental condition, and it affects approximately 5% of children worldwide. ADHD involves difficulties with the executive control of behaviour (Castellanos et al., 2006). Executive functions refer to the mental processes that can be consciously controlled and employed when automatic reactions are insufficient. In such instances, an individual must pause and replan to achieve a desired goal (Diamond, 2013). Research has shown that children with ADHD exhibit impairment in at least one of the core executive functioning domains: inhibitory control, working memory, or set-shifting (Kofler et al., 2019; but see Willcutt et al., 2005, for a discussion). This poses a significant challenge that can disrupt adaptive functioning and lead to academic or occupational disadvantage (Dvorsky & Langberg, 2019; Paralik et al., 2024). Therefore, exploring the underlying reasons for impairments in executive functioning is worthwhile.

According to Barkley's inhibition theory, impaired inhibition leads to difficulties in executive functioning, which is believed to underlie the symptoms of ADHD. (Barkley, 1997; see also Panah et al., 2025, for an updated version). Inhibition is a critical executive function because individuals must withhold their habitual response before performing a new behaviour to solve problems. It is commonly observed that children with ADHD face challenges in this area.

Prepotent response inhibition (hereafter referred to as inhibition) is the intentional suppression of a response that enables an individual to stop and replan. When ineffective, behaviour may appear disorganised or impulsive. The literature presents varying findings regarding inhibition performance in individuals with ADHD. Some studies report no impairment in inhibition (Castellanos et al., 2006; Engelhardt et al., 2008), while others indicate poorer performance than neurotypical individuals (Orhan et al., 2023; Wodka et al., 2007). The impact of demands on working memory (WM) could be key to understanding the inconsistent results.

WM is the system responsible for maintaining and manipulating information. Achieving this task necessitates the involvement of the central executive (CE) component of WM to coordinate the flow of information within the subsystems (i.e., the auditory loop and the visuospatial sketchpad; Baddeley & Hitch, 1974). Some scientists argue that inhibition impairment is secondary in ADHD, and a WM deficit could underlie inhibition impairment (Castellanos et al., 2006). Recently, Kofler et al., (2024) tested this proposition using a task that included two levels of WM load. The authors reported that a higher WM load negatively affected inhibition performance among children with ADHD compared to children with anxiety disorder. These findings support conceptual models that identify working memory as a fundamental causal mechanism influencing performance on inhibition tasks.

The CE is the component of working memory that manages higher-order control processes, such as focusing attention, inhibiting irrelevant responses, switching between tasks, and updating information. Research indicates that CE is more impaired in children with ADHD compared to their typically developing peers (Fosco et al., 2020; Rapport et al., 2008). Additionally, findings suggest that among children with ADHD, CE is more compromised than other WM systems (Roodenrys et al., 2001). These findings suggest that when evaluated using a task that employs a dual-task paradigm, they may exhibit deficits in managing simultaneous cognitive processes. It is crucial to manage co-occurring processes, as solving practical problems necessitates retaining information as instructions while effectively employing executive functions. A curious question is whether there is a link between impaired CE and the inhibition difficulties children with ADHD experience.

There is an ongoing debate about whether the primary cause of the cognitive deficits seen in ADHD is due to specific impairments in executive processes or general impairment in allocating mental resources (Dörrenbächer & Kray, 2019). An intriguing question is whether CE has a structural impairment or if a fault in resource allocation causes CE to fail. Notably, it has been proposed that CE is a limited resource pool, and the available resources must be shared between ongoing cognitive operations. The central executive's optimal functioning may depend on an efficient supply of resources, and a shortage could lead to failure in effectively holding or manipulating information, which may eventually result in challenges in inhibition and controlling impulses.

The cognitive-energetic model (Sergeant, 2000) advocates that individuals with ADHD have a core deficit concerning energetic resources, manifesting as inconsistent or suboptimal performance across tasks. Children with ADHD often demonstrate significant intra-individual variability in multiple cognitive domains, meaning their performance can fluctuate significantly from one moment to the next, even within the same task (Vaurio et al., 2009). These fluctuations provide some support for the cognitive-energetic model's proposal and suggest that these children may struggle to allocate attentional and cognitive resources over time.

Gualtieri and Johnson (2006) examined the efficiency of attentional resource allocation among 350 children and young adults with and without ADHD. They wanted to see whether the ADHD group would show inefficient resource allocation and how this would change from age 10 to 29. Participants went through a battery of neurocognitive tests. The key finding of this cross-sectional study was that the performance of both groups improved with age; however, a critical difference was that controls improved by increasing speed, whereas ADHD participants relied on trading speed for accuracy. The authors of the study interpreted their results to mean that the ADHD group exhibited an inefficiency in the way they allocate their attentional resources. In the control group, as participants matured, they improved their response speed without compromising accuracy, demonstrating efficient resource utilisation. In contrast, those with ADHD could only improve accuracy by slowing down, indicating a trade-off. Thus, the observed trade-off can be taken as further evidence that ADHD participants allocate cognitive resources less optimally. An impairment in allocating resources would be related to the observed inhibitory difficulty among children with ADHD.

As a method of investigation, the dual-task paradigms allow evaluating efficiency in managing competing cognitive processes, which require dividing and allocating resources between concurrent demands. This involves engaging with two tasks simultaneously, which in some studies takes the form of holding a WM load while performing a second task. Multiple authors who used the dual-task paradigm and taxed CE argued that their results imply a resource allocation problem among children with ADHD (Greenham, 1998).

Researchers have shown that imposing maintenance demands on the CE impairs performance in various attention and updating tests. For instance, Kofler et al. (2010) found that placing demands on the CE adversely impacted attentive behaviour among children with ADHD, further suggesting that the observed difficulties could stem from an issue with resource allocation. The current literature lacks information on whether poor inhibition performance arises from difficulty maintaining information, a flaw in resource allocation, or a weakness of the inhibition mechanism itself. Therefore, the current study aimed to disentangle these processes to investigate whether the problem lies in maintaining information, the inhibition mechanism, or resource allocation.

Seymour et al. (2016) investigated the effect of higher cognitive demand on inhibition performance. Children aged 8 to 12, both with and without ADHD, completed a simple Go/no-go task followed by a complex Go/no-go task involving increased cognitive load. The results indicated that boys with ADHD were more impaired in both tasks compared to their typically developing (TD) peers. On the other hand, girls with ADHD were impaired only in the complex Go/no-go Task when compared to TD girls. There was no performance difference between the girls with and without ADHD in the first level when there was no WM load. However, increased maintenance demand impaired the inhibition performance of girls with ADHD.

These findings provide partial evidence that children with ADHD can perform at the expected level, but their inhibition performance would be impaired when WM demand increases. Considering these findings, the present study hypothesised that the inhibition scores in both groups should not be significantly different when there is no WM load. On the other hand, overall inhibition scores in the ADHD group should be lower in the presence of WM load.

Aforementioned, Seymour et al.’s (2016) study included only two levels: the first involved no load, while the second required recalling a very complex rule that also acted as the WM load. Furthermore, the WM load did not increase gradually, making it impossible to observe how the groups would respond to a gradually increasing WM load. Unlike Seymour’s work, the present study's Go/no-go Task included four distinct load levels to address this gap. The first level had no load, but the load increased gradually in the subsequent three levels. Considering the previous findings, in the present study, it has been hypothesised that a gradual increase in WM load should result in a gradual decrease in the inhibition performance of the ADHD group.

Some studies have shown that increased WM load results in impaired performance. However, other studies demonstrate that increasing WM load can benefit certain tasks. The cognitive load theory suggests that increasing cognitive demands can overwhelm working memory, resulting in poorer performance (Barrouillet et al., 2007). In contrast, the perceptual load theory suggests that increased attentional load may enhance performance by freeing up remaining free attention capacity that can be engaged with irrelevant stimuli. (Lavie et al., 2004). Notably, Simon et al. (2016) investigated whether WM load influences early distracter processing. Twenty-three healthy young participants completed a primary visual WM task under high and low load conditions while instructed to ignore irrelevant auditory stimuli. Findings showed that increased WM load was associated with enhanced attentional engagement.

Similarly, Kim et al. (2005) showed that increased WM load could result in better resistance to distractor interference among neurotypical adults. These findings suggest increased WM load may be associated with enhanced attentional engagement. However, the mechanism by which this happens is unclear. It can be speculated that load may be linked to concentration, and a certain amount of WM load could be critical for initiating concentration. Additionally, maintaining WM load could be related to maintaining concentration. The question asked at this point is whether a greater load would improve inhibition performance in the neurotypical group and whether the ADHD group might be affected differently. The present study provides an opportunity to observe this phenomenon and compare it between groups of children with and without ADHD. In the present study, a higher load is expected to increase the performance of neurotypical children; however, it should influence the ADHD group's performance in the opposite direction.

In sum, to date, no study has examined the influence of maintenance demand on response inhibition performance using a dual-task paradigm that allows for a gradual increase in WM load across four different levels among children with ADHD. Considering the existing evidence, the present study hypothesises that: 1) the inhibition scores in both the ADHD and non-ADHD groups should not significantly differ when there is no WM demand, 2) overall inhibition scores in the ADHD group should be lower than those in the control group in the presence of WM demand, and 3) a gradual increase in WM load should lead to a gradual decline in the inhibition performance of the ADHD group. However, it is anticipated that a higher load could enhance the performance of TD children.

Method

Participants

The ADHD group consisted of 40 children (30 males, 10 females, M_{age} = 8.92 years, age range: 7-11 years) who were residents of Cyprus. All children were Turkish language speakers and primary school students. They were recruited in the Burhan Nalbantoglu Hospital's child-psychiatry outpatient unit, and all were drug naïve. The consecutive sampling method was used to recruit participants. Children who applied to the hospital and met the inclusion criteria were included until the required number of participants (N = 40) was obtained. The inclusion criteria comprised an ADHD diagnosis, being a Turkish language speaker, and having at least one parent available to complete the parent consent form. Exclusion criteria included an estimated IQ of less than 80 and a known diagnosis of a neurological condition, such as seizures, as these could affect the test results. Participation was voluntary, and children were compensated at the end of the study. Informed consent was obtained from both parents and children prior to the commencement of data collection.

For the control group, 40 children (30 males; 10 females; M_{age} = 9.05 years, age range: 7-11 years) were recruited from a primary school in Nicosia. The mean ages of children in the ADHD and control groups were not significantly different from each other, $t(78) = -0.48$, $p > .05$ (see Table 1). All the children were born and raised in Cyprus. The selection was carried out using an anonymous list. The list included only student number, age, and gender and comprised the students whose parents permitted participation. Children were recruited based on the age and gender distribution in the ADHD group. Implementing such a strategy aimed to ensure the groups were equal in age and gender. The inclusion criteria were the parents' consent and being a speaker of the Turkish language. Exclusion criteria included an estimated IQ of less than 80 and a neurological or psychiatric diagnosis that could affect the test results.

Ethical approval was obtained from Near East University's IRB. Five children's data were discarded. Four were discarded because their estimated IQ was below 80, and one child informed the experimenter during the testing that they did not want to continue the session. Eventually, each group included 40 children.

G*Power software (Faul et al., 2007) was utilised to determine the necessary sample size. For an effect size of 0.25, α = 0.05, power (1–β) = 0.80, two groups, and four repetitions, 34 participants were required in each group for a mixed repeated-measures ANOVA to achieve the desired power.

Table 1
Means and standard deviations of age and estimated intelligence in clinical and control groups

Variable	ADHD (N= 40)		Control (N= 40)		t(df)
	M	SD	M	SD	
Children's age	8.92	1.37	9.05	1.43	-0.48(78)[a]
Father's age	41.1	6.18	41.5	3.64	-0.35(78)
Mother's age	37.4	5.34	39.4	3.08	-2.05(78)
Estimated intelligence	98.4	10.1	103.5	11.8	-3.54(78)[a]

Note. [a]Equal variances assumed because Levene's test for equality > 0.05.

Measures

Go/no-go Task

The Go/no-go Task was a variation of the Sternberg Memory Task (Sternberg, 1975). The version modified by Hester and Garavan (2005) was used in this study. This task was developed to assess the inhibitory ability of prepotent motor responses with and without a WM load. In the present study, modifications were made to the number of runs and trials to make this measure suitable for children.

E-Prime Version 2.0 computer program was used to present the stimuli in the 50-point Arial font on a Windows-based computer with a 17-inch colour monitor (see Figure 1). There were four runs, each consisting of fifty trials. Initially, participants received a short practice session. Then, the first run followed, which was a go/no-go run without any cognitive load. Participants were instructed to press the keyboard key ‘space bar’ for all the letters on the screen but to withhold their response when the ‘X’ appeared. Each trial took 2,500 msec. and included the presentation of a single letter for 1,750 msec. and then a blank black screen for the concluding 750 msec. In the second run, the WM load was introduced. Participants were presented with two capital letters (D and H) that appeared in white on a black background. These letters constituted the cognitive load (i.e., memory list). The memory list was presented for 6 seconds and then immediately followed by a 6-second rehearsal period. Participants were instructed to rehearse these letters and press the keyboard key ‘space bar’ for any letters on the screen, but to withhold their response if one of the letters from the memory list appeared. Then, the third run is followed by three letters (C, T, and S). Then the fourth run followed by four letters (L, U, A and N). Increasing the number of letters served to increase the load that was maintained in the working memory. In each load condition, the obtained output score was the total number of correctly inhibited responses (i.e., total correct). Ultimately, four different runs with varying load conditions resulted in four distinct raw scores. Higher scores indicated a better inhibition performance, and the obtained raw scores in each run were used in the analysis.

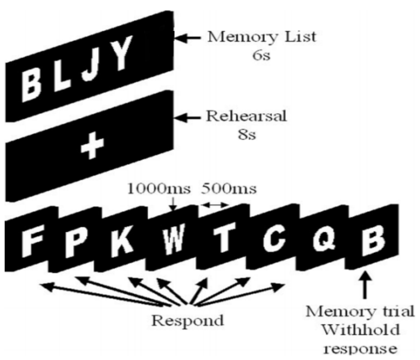

Figure 1. Go/no-go Task with working memory load

Procedure

Data from the ADHD group were collected in the … Hospital's child psychiatry outpatient clinic. This is the biggest government hospital in … . Families applied to the hospital for an evaluation of their children. The diagnostic process involved a multi-step approach. In the first session, the child psychiatrist interviewed the parents and child to rule out autism spectrum disorder, intellectual disability, traumatic brain injury, and seizure disorders. Then, an ADHD symptom checklist was completed (American Psychiatric Association, 2013). The information about medical history was recorded, and a general medical examination was conducted. If ADHD was suspected, then the Revised Conner's Parent Rating Scale- Long Form (Bicakci et al., 2013) and Revised Conner's Teacher Rating Scale-Long Form (Kaner et al., 2011) were given to be returned in the following meeting.

In the second session, all the collected information was considered together. If there was clear evidence for six or more symptoms from any one of the inattention or hyperactivity-impulsivity domains, symptoms were present in two or more settings, symptoms reduced the quality of practical functioning, and if another mental disorder could not better explain symptoms, then the diagnosis of ADHD was made. When the ADHD diagnosis was confirmed, the parents and the children were informed about the study, and they were offered a chance to take part. Participation was voluntary, and if the family and the child were willing to participate, they proceeded to the testing room. The parents and children completed and signed an informed consent form indicating their willingness to participate and to allow the use of collected data for publication purposes.

Data from the control group were collected at one of the primary schools in Nicosia. After gaining the necessary permissions, the numbers, ages, and genders of 500 students were recorded on paper, and a list was prepared for recruiting 40 participants for the control group.

The data collection process was identical to that used in the clinical group. Finally, all the children recruited for the study completed the Wechsler Abbreviated Scale of Intelligence - Second Edition. An estimate of general intellectual ability was obtained by combining the results of the Vocabulary and Matrix Reasoning subtests. Evidence in the literature indicates that these two subtests provide a reliable assessment of the full-scale estimated intelligence (Wechsler, 2011).

Data Analytic Strategy

In the present study, the dependent variable was the inhibition performance measured with the Go/no-go Task. The groups and the conditions were the independent variables. A repeated measures design was employed. For investigating the influence of the WM demand on inhibition performance, the effect of maintaining varying levels of WM load was compared between two groups, using mixed repeated-measures ANOVA with the group (clinical and control) as the between-subjects factor and the WM load condition (zero, low, medium, and high) as the within-subjects factor. A Bonferroni post hoc test was conducted.

Results

The assumptions of the repeated measures ANOVA were tested. Mauchly's test of sphericity was marginally significant ($p = 0.04$), so the Greenhouse-Geisser estimate of the F statistic was used. The homogeneity of variance was checked by Levene's test. Levene's test was significant for the third load condition, but the number of subjects in each group was equal. Box's test of equality of covariance matrices was insignificant ($p = .36$). All the analysis assumptions were met.

Mixed repeated measures ANOVA results showed a main effect of group $F(1, 78) = 16.12$, $p < .001$, $\eta_p^2 = 0.17$, meaning that inhibition scores significantly differed between the groups. The control group's mean inhibition scores were higher in each load condition. However, between-group pairwise comparisons showed that the two group's inhibition scores were not significantly different in the first load condition when there was no WM load, $p = .36$. Group differences in average inhibition scores can be observed in Table 2.

Table 2

Means, mean differences and standard deviations of inhibition scores across the load conditions in the clinical and control group

	Clinical (N = 40)		Control (N = 40)		Mean difference	Cohen's d
Condition	M	SD	M	SD		
Condition 1	12.05	1.99	12.45	1.89	0.4	0.21
Condition 2	9.70	2.13	10.88	2.37	1.17	0.52
Condition 3	8.0	2.16	9.68	3.17	1.67	0.62
Condition 4	7.08	2.42	10.18	3.14	3.10	1.11

Note. Condition 1 included no letters to maintain. Condition 2 included two letters (D, H), condition 3 included three letters (C, T and M), and condition 4 included four letters (L, U, A and N) to maintain as the WM load.

There was a significant main effect of load on inhibition scores, $F(2.75, 214.18) = 57.86$, $p < .001$, $\eta_p^2 = 0.42$. The amount of load maintained in the WM affected the inhibition scores. Furthermore, there was a significant interaction effect between the load and the group, $F(2.75, 214.18) = 6.68$, $p < .001$, $\eta_p^2 = 0.08$. This showed that participants' inhibition scores differed across the load conditions depending on whether they were in the clinical or the control group. In other words, increased load affected the two groups differently. In the clinical group, there was a gradual decrease in the mean prepotent motor response inhibition scores from condition one to condition four. The lowest score was obtained in the fourth condition, where the amount of WM load was the highest.

When the mean differences were investigated using the pairwise comparisons, it appeared that the ADHD group's inhibition scores were significantly different from each other in each load condition, $p < .05$. This finding showed that increased load resulted in decreased inhibition scores and the scores among the conditions, were significantly different from each other.

On the other hand, in the control group, increased WM load resulted in a decrease in the prepotent motor response inhibition performance from condition 1 to condition 3. However, in the fourth load condition, the prepotent motor response inhibition performance increased, where the amount of WM load was the highest. The prepotent motor response inhibition scores of load conditions 1-2 and 2-3 differed significantly, but conditions 3 and 4 did not ($p = .26$).

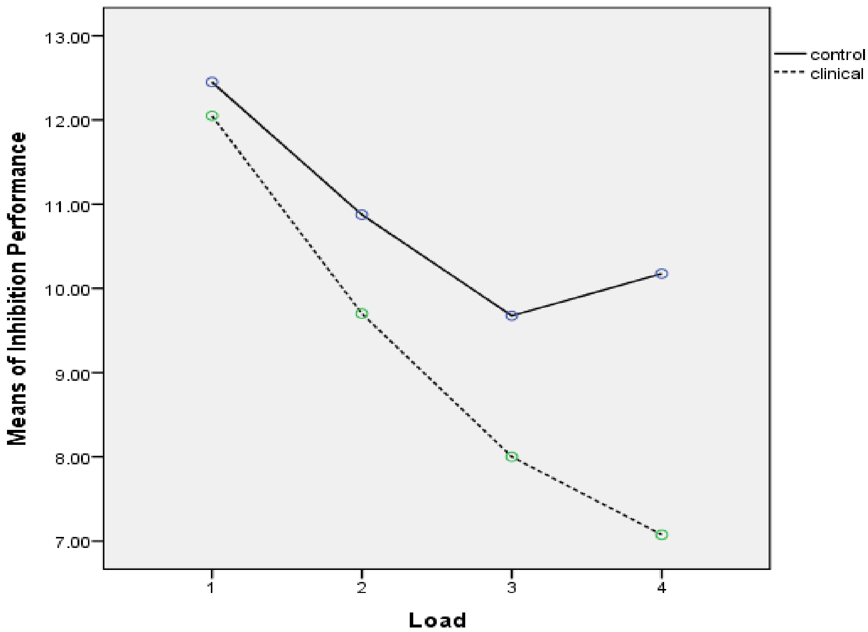

Figure 2. Mean scores of inhibition performance across the four load conditions for the clinical and control groups. The main effect of load and group was observed, with controls outperforming the ADHD group.

The estimated marginal means and interaction graph are presented in Figure 2. The graph shows that the group performances were similar in the first load condition, and there was no significant difference between inhibition scores. The second and third load conditions resulted in decreased prepotent motor response inhibition performance in both groups. However, in the fourth load condition, heavier load decreased performance in the ADHD group but increased the inhibition performance of the non-ADHD group. When the slope of lines is investigated, it can be seen that the clinical group's slope is steeper than the non-ADHD group, implying that increased load had a significant negative impact on the inhibition performance of the ADHD group but not on the inhibition performance of the non-ADHD group.

Discussion

The present study investigated whether maintaining WM load influences inhibition performance differently among children with and without ADHD. It was hypothesised that there would be no difference without WM load. However, in the presence of load, the ADHD group's inhibition performance was expected to be poorer compared to the non-ADHD group, and the children with ADHD were anticipated to experience a gradual decrease as the WM load increased. Additionally, it was of particular interest to determine whether increased load could positively influence the control group's performance under any load conditions. Results supported the hypotheses. There was no significant difference in the inhibition performance of the two groups when there was no WM load. On the other hand, in the presence of a load, the ADHD group scored lower under every load condition, and increased load resulted in a gradual decline in their inhibition performance. They performed the worst under the final condition with a heavier load, while the control group's performance showed improvement.

The first finding demonstrates no significant difference in inhibition performance between groups when there is no WM demand. This aligns with studies in the literature that used the Go/no-go Task without any WM load and found no inhibition weakness among children with ADHD (Kofler et al., 2019; Scheres et al., 2004; Wright et al., 2014). Conversely, one study incorporating increased WM load within the Go/no-go Task reported impaired inhibition performance (Seymour et al., 2016). Consistent with existing literature, the current study's findings demonstrate that inhibition performance in the ADHD group changes significantly only when the WM load is introduced. It can be argued that children with ADHD can allocate sufficient resources to meet the controlled attention demands of the Go/no-go Task when there is no WM load. The present finding supports the notion that poorer inhibition performance in ADHD may mainly arise from underlying deficits in resource allocation rather than solely impaired inhibitory mechanism.

The second finding of this study shows that, under WM load, the ADHD group's inhibition performance is poorer across all load conditions. The increasing load caused a steady decline from condition one to condition four. The Bonferroni post hoc test for pairwise comparisons revealed that inhibition scores differed significantly between each load condition. This result demonstrates that, within the ADHD group, maintaining WM load negatively impacted inhibition performance. A curious question is whether WM load interferes with maintenance or manipulation.

Notably, in the Go/no-go Task, the load was gradually increased across the conditions. However, the level of controlled attention demand -the number of stimuli to inhibit- remained consistent. Therefore, it can be argued that load was the sole factor affecting inhibition performance. Additionally, when asked at the end of each run, children recalled the maintained letters. This suggests that lower inhibition scores in the ADHD group were not due to an inability to maintain the load in working memory. Instead, it can be inferred that the lower scores resulted from poorer execution of inhibition.

Previous research has indicated that children with ADHD display pronounced deficits in CE functioning, particularly under conditions demanding simultaneous cognitive processes

(Fosco et al., 2020; Rapport et al., 2008). The present findings suggest that CE itself may not be faulty, but when there are not enough resources to support simultaneous functions, some of these functions appear defective. Therefore, when considering the role of CE in impaired executive functioning in ADHD, we need to consider the role of insufficient resource allocation. What we describe as inhibition or working memory deficits in ADHD may sometimes actually reflect an underlying issue with consistent resource allocation.

The present findings align with previous studies that utilised dual-task paradigms to examine task-switching, decision-making, and cognitive control, reporting that increased cognitive demands adversely impact executive functioning in children with ADHD due to insufficient resource allocation (Dörrenbächer & Kray, 2019; Fabio et al., 2020; Greenham, 1998; Gualtieri & Johnson, 2006). Accumulating evidence suggests that children with ADHD may have difficulty allocating enough controlled attention resources to manage increased task demands, especially in situations that require coordination of multiple tasks.

The resource allocation theory of attention proposes that simultaneous cognitive processes must share limited resources. Performance can decline if one process fails to leave enough resources for other processes to function (Wickens et al., 1980). For instance, Hester and Garavan (2005) used the Go/no-go Task where neurotypical adult participants were given increasing amounts of letters while trying to inhibit their prepotent responses. The study results showed that increased WM load reduced inhibition performance. The authors argued that both functions should rely on a common attentional source.

Reports suggest that maintenance and inhibition abilities tap into the same energetic source (Pennington & Ozonoff, 1996; Roberts et al., 1994). Based on the present findings, it can be speculated that when resources are limited, maintaining WM load may consume most of the controlled attention resources, and the remaining resources may not be sufficient to support optimal inhibition performance among children with ADHD.

In both groups, an increased load reduced inhibition performance until the third condition. However, in the fourth condition, the control group's performance improved, whereas the clinical group's performance continued to decline. The largest mean difference between the two groups was recorded in the fourth load condition (Cohen's d = 1.11). This indicates a clear difference between groups and shows that the ADHD group did not meet the task demand. This finding suggests that children with ADHD faced the most significant difficulty in the fourth condition, where the load was heaviest. Conversely, the non-ADHD group's increased inhibition scores in the fourth condition indicate that they are oriented to the task and can allocate sufficient resources to meet the increasing task demand.

The present study shows that children in the non-ADHD group did not experience resource depletion. According to perceptual load theory, the amount of perceptual load influences the efficiency of processing distractors (Lavie et al., 2004). In this context, (Forster & Lavie, 2008) examined the effect of load on task-irrelevant distractors. Based on their results, the authors concluded that the distracting impact of task-irrelevant stimuli can be reduced with increased WM load. The findings of the present study extend the literature by showing that inhibition performance could improve with higher WM demand among TD children. This suggests a possible optimal cognitive load level for boosting attentional engagement. It is plausible that an optimal WM load is necessary for concentration, and maintaining the right amount of information may be an essential part of this process. This idea warrants further research and could lead to new insights into concentration difficulties within the ADHD population.

Theoretical Implications

The present results indicate that maintaining load consumes controlled attention resources, with higher maintenance demand requiring more resources. Optimal performance can be achieved only if sufficient resources support ongoing processes. These findings corroborate the resource allocation theory of attention, demonstrating that when the maintenance and manipulation of information are activated simultaneously, they compete for the available attention resources. The results of the present study provide further evidence that the CE serves as a common pool of controlled attention, highlighting the trade-off between controlled functions. This challenges the independent resources of attention hypothesis and endorses the idea of a singular, common source for controlled attention.

The present results suggest that active maintenance of working memory load may be linked to concentration ability. However, the literature requires a more precise and improved definition of concentration. Based on the current findings, it can be speculated that when load becomes excessive, concentration may fail. This could relate to ADHD symptoms such as difficulty sustaining attention on tasks, inability to follow instructions or conversations, and challenges in organising tasks and activities.

Children with ADHD have been reported to have difficulty sustaining their attention (APA, 2013). However, it should be noted that children with ADHD can play video games for extended periods, suggesting that it is easier for them to maintain attention on simple tasks where the WM load is not high. Therefore, it could be argued that concentration differs from maintaining attention monotonously.

The results reported in this study suggest that efficiently maintaining a certain level of WM load may be necessary for concentration to occur. For instance, sustained attention is engaged when an individual observes the flight of balloons in the air for several minutes without initiating any controlled cognitive processes. Conversely, concentration becomes essential when individuals are asked to categorise these balloons based on their colour and then count the number of balloons in each category—this imposes a WM load. Completing this task requires retaining information (i.e., instructions, category names, and the number of airborne balloons) until all the balloons are counted and categorised. This task necessitates keeping the information in an active WM state. If maintaining information is effortful and aversive, a child with ADHD may quickly disengage from the task due to the difficulties they encounter while trying to concentrate.

Clinical Implications

WM is involved in most academic tasks and challenges that children encounter in a school environment. In the present study, increasing the load by one letter at a time allowed for pinpointing the breaking point in performance among children with ADHD. In an educational task, if their WM is not overloaded beyond what can be maintained, improved executive functioning performance can be achieved. Findings demonstrate that WM load is a factor that must be considered in tasks where optimal executive functioning performance is desired among children with ADHD.

Rapport et al. (2009) reported that increased WM load results in a greater amount of hyperactivity. In the present study, it was found that heightened WM load leads to impaired response inhibition performance. It is reasonable to suggest that increased WM load would lead to more hyperactivity through impaired inhibition performance. One can speculate that heightened WM load impairs inhibition, subsequently causing more frequent hyperactivity and impulsivity. Therefore, it can be suggested that reducing the WM load for a child with ADHD may enhance inhibition efficiency and help decrease hyperactivity.

Excessive resource consumption to maintain WM load could relate to other symptoms of ADHD, such as difficulty focusing on tasks, disorganisation, and an inability to follow instructions. One could argue that if the maintenance limit is exceeded, children with ADHD may struggle to sustain their attention effectively.

Limitations and Future Directions

The present study investigated the effect of WM demand on inhibition performance. Although it has been demonstrated that a higher load adversely affects inhibition, it cannot be claimed that the remaining executive functions will be similarly impacted. Therefore, the effect of maintenance demand on the performance of the other executive functions could be examined in a future study.

The results of the present study suggest that resource allocation and concentration are interrelated. Maintenance performance may be linked to appearance and the quality of concentration. However, concentration was not the primary focus of this investigation. Therefore, the current design does not permit conclusions about the dynamics of concentration. Future research should examine the effect of WM load on concentration efficiency using an appropriate paradigm. Importantly, in the literature, the concepts of sustained attention and concentration have been used interchangeably. Nevertheless, the findings of this study suggest that these can be distinct mental capacities. Therefore, there is a need to distinguish concentration from sustained attention.

Furthermore, this study involved children aged between 7 and 11, which limits the ability to generalise the results to adolescents and adults. Likewise, not distinguishing between ADHD subtypes can be considered a limitation of the present study. Therefore, future research should explore this separation and investigate potential sex differences in the relationship between resource allocation and inhibition performance.

Conclusion

The present study investigated the role of WM load in the reported inhibition impairment among children with ADHD. The findings support the notion that atypical resource allocation underlies impaired inhibition performance. Unlike neurotypical children, children with ADHD are unable to allocate sufficient resources to increase their effort in meeting task demands to achieve optimal inhibition performance. Future studies should investigate the impact of atypical resource allocation on other executive functions that are also known to be impaired. The present findings have important implications for impaired concentration within the ADHD population.

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