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ADHD and the avoidance of mental effort: the role of response inhibition and avoidance motivation

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ABSTRACT

Objective: The tendency of people with ADHD to avoid tasks that require mental effort impacts their academic achievement. Findings in the literature suggest that children with ADHD find cognitive tasks more effortful and uncomfortable than their typically developing peers. However, neuropsychological processes contributing to this remain unclear. The present study investigated whether the relationship between prepotent motor response inhibition and avoiding mental effort is mediated by the ability to resist avoidance motivation and whether this proposed mediation mechanism is contingent on ADHD diagnosis.

Method: 40 children with ADHD and 40 gender and age-matched typically developing peers participated in the study. They completed the Cognitive Effort Avoidance Measure, the Go/No-go Task, and the Reinforcement Sensitivity Theory-Personality Questionnaire-Children. Mediation and moderated mediation analyses were employed to test the hypotheses.

Results: Children with ADHD scored lower in response inhibition and resisting avoidance motivation. Poorer scores in these variables were associated with a higher avoidance rate. Moreover, the ability to resist avoidance motivation completely mediated the relationship between response inhibition and avoidance rate only among children with ADHD.

Conclusion: Findings imply that poorer response inhibition led to an increase in avoidance motivation among children with ADHD, which becomes challenging to regulate effectively due to an impairment in the ability to resist avoidance motivation. Theoretical and clinical implications are discussed.

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ADHD; avoiding mental effort; rRST-BIS; resisting avoidance motivation; prepotent motor response inhibition

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental condition with an onset during childhood, and a persistent pattern of inattention and disinhibition marks it. The Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5; American Psychiatric Association [APA], 2013) describes three presentations: predominantly inattentive, predominantly hyperactive-impulsive, and combined. With an estimated prevalence rate of 5% on average globally (Sayal et al., 2017), ADHD is one of the most frequently encountered childhood disorders. It is strongly linked to academic underachievement (Daley & Birchwood, 2010) and increased school dropout rates (Fredriksen et al., 2014). Zoromski et al. (2021) showed in a representative sample of children with ADHD that avoiding tasks that require mental effort was the strongest predictor of their academic impairment.

Avoiding mental effort is one of the several symptoms of ADHD. The DSM-5 states that a child with ADHD "often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (e.g., schoolwork or homework; for older adolescents and adults, preparing reports, completing forms, reviewing lengthy papers)" (APA, 2013, p. 59). This avoidance can be described as a reluctance to use cognitive capacities (e.g., planning) to engage and solve effortful problems. An intriguing question is why an individual would avoid mental effort.

Patzelt et al. (2019) stated that people tend to choose tasks with less cognitive demand because cognitive control is effortful, which imposes a psychological cost. Two contributing factors to avoiding mental effort are cognitive efficiency and motivational regulation. If a task is experienced as difficult because an individual lacks the

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required level of cognitive capacity, then they would avoid it. On the other hand, regarding the motivation, two possibilities exist. Either individual may not have enough motivation to complete a task or may lack the capacity to resist avoidance motivation caused by the task's difficulty.

Existing studies in the literature that investigated this behavior demonstrated no difference between children with and without ADHD in terms of effort discounting (Hazell et al., 1999; Winter et al., 2019). On the other hand, some studies showed that non-patient adults with higher rates of ADHD symptoms reported exerting higher mental effort (Hsu et al., 2017). This result has not been replicated in the ADHD patient population and awaits further investigation. Nevertheless, existing findings suggest that children with ADHD find cognitive tasks more effortful (Mies et al., 2019).

There is a gap in the literature regarding the specific factors contributing to the rate of avoiding mental effort among children with ADHD. Considering previous research findings, the present study aims to add to the literature by studying the influence of specific neuropsychological constructs to explain the higher rate of avoiding mental effort among these children. The main question asked in this study is whether an atypical prepotent motor response inhibition performance and ability to resist avoidance motivation contribute to the higher rate of avoiding mental effort among children with ADHD.

Prepotent motor response inhibition and rate of avoiding mental effort

The existing evidence in the literature links prepotent motor response inhibition (hereafter referred to as response inhibition) to task persistence (Karsdorp et al., 2014; Torgrimson et al., 2021). The impairment of response inhibition in children with ADHD is well documented. When assessed by the Go/no-go Task, they have been observed to have poorer performance than their typically developing (TD) peers (Wright et al., 2014).

Study findings demonstrate that response inhibition is integral to efficient cognitive control (Aron, 2007; Chambers et al., 2009). For example, in a longitudinal study, Berlin et al. (2004) demonstrated that response inhibition performance positively predicted non-verbal working memory, verbal working memory, self-regulation of affect, and verbal fluency among children with ADHD. Findings suggest that a weakness in inhibiting habitual responses can decrease the quality of cognitive processing.

Reviewed findings suggest that poorer response inhibition can be related to experiencing higher task difficulty. Previously, Blaum et al. (2002) showed that cognitive performance is negatively related to task difficulty. However, there is a gap in the literature regarding the link between response inhibition and subjective experience of task difficulty.

For this reason, the present study will investigate this link by asking children how much difficulty they experienced after each test. Obtaining a significant negative correlation between response inhibition and the level of trouble can be taken as evidence that poorer response inhibition is related to experiencing more difficulty in cognitive tasks.

In sum, poorer response inhibition could be related to higher task difficulty and lead to higher avoidance motivation. It can be argued that when a child struggles with a task, this can produce negative physical feelings and an unsettled psychological state. All these adverse stimuli can increase a child's motivation to avoid a cognitive task. For this reason, in the present study, poorer response inhibition is expected to predict a higher rate of avoiding mental effort among children with ADHD.

In an academic setting, a child must engage and persist until an assignment is completed. Completing an assignment partly depends on resisting avoidance motivation. For this reason, in the present study, the ability to resist avoidance motivation is anticipated to contribute to the rate of avoiding mental effort. No study has investigated whether the ability to resist avoidance motivation is related to the frequency of avoiding mental effort.

The BIS and resisting avoidance motivation

The revised reinforcement sensitivity theory (rRST; Gray & McNaughton, 2000) proposes three brain-behavior systems (i.e., behavioral approach system; BAS; fight, flight, freeze system; FFFS, and behavioral inhibition system; BIS) to account for the approach, avoidance, and cautious behaviors, respectively. BAS activation produces approach motivation, while FFFS activation produces avoidance motivation. The rRST defines the BIS as a control mechanism between the BAS and the FFFS: The BIS is a comparator mechanism involved in detecting and resolving goal conflict (Amodio et al., 2008). When it detects goal conflict, it switches to control mode and regulates motivation for adaptive behavior. BIS activation leads to a cautious approach, and it can inhibit both the BAS and the FFFS-related motivation. By so doing, it helps to manage behaviors until the conflict is resolved (Corr &

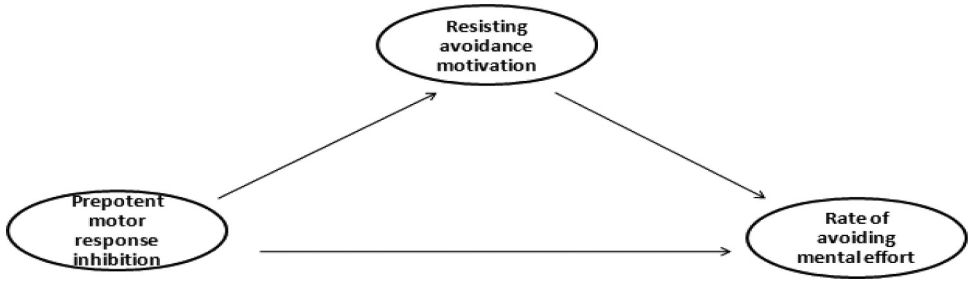

Figure 1. The simple mediation model shows the indirect effect of the prepotent motor response inhibition performance on the rate of avoiding mental effort through the ability to resist avoidance motivation (i.e., BIS).

McNaughton, 2008). Some fMRI study results support the notion that a common neural mechanism of BIS inhibits both avoidance and approach-related motivation (Gable et al., 2018; Kelley, 2015).

Leaving tasks uncompleted is a typical behavioral pattern among children with ADHD (APA, 2013). A challenging cognitive task can be perceived as aversive and trigger the FFFS activity (Kennis et al., 2013). Activation of the FFFS could increase avoidance motivation and result in fleeing if not adequately regulated by the BIS. In such circumstances, the BIS may play a critical role by helping children resist the temptation of fleeing. Notably, when the BIS activity level is low, children would be weak in inhibiting the FFFS-related avoidance motivation and behavior. A hypoactive BIS could indicate a weakened capacity to endure the stress of aversive stimuli and, thus, a higher tendency to flee or avoid the situation. In support of this argument, Findley (2014) proposed that when weak BIS cannot inhibit the FFFS-induced avoidance motivation, this could result in self-control failure. Moreover, in a review article, Gable et al. (2018) argued that hypoactivity of the BIS could account for unregulated withdrawal behaviors.

Based on Gray's (1982) reinforcement sensitivity theory, Quay (1997) has proposed that an under-responsive BIS plays a critical role in ADHD symptoms. Electrophysiological evidence exists in the literature to support Quay's hypoactive BIS hypothesis. Previously, Fowles (1983) demonstrated that activity in the BIS is linked to increases in skin conductance levels among non-patient adults. Later studies investigated this relationship among children with and without ADHD. For example, Iaboni et al. (1997) provided evidence for under-responsive BIS by showing that in contrast with their TD peers, the children with ADHD do not exhibit increased skin conductance levels during the extinction phase of a repetitive motor task and, hence, remain at the same level of arousal. More recently, Bellato et al. (2020) conducted a systematic review of the literature and identified nine studies that reported lower skin conductance levels among children with ADHD compared to TD children. Seven of these studies reported hypoactivation during cognitive tasks and two during resting. Existing evidence in the literature supports that children with ADHD have a lower BIS level when compared to TD children.

Study findings suggest that hypoactivity of the BIS is related to poorer stimulation of cortical regions that facilitate effortful control (Blair et al., 2004; Bunford et al., 2017; Prabhakaran et al., 2011). Therefore, children with ADHD could have difficulty employing effortful control and resisting avoidance motivation. On the other hand, having an optimal BIS level could provide TD children with the efficient ability to resist avoidance motivation. In other words, an optimal BIS level among TD children should facilitate sufficient arousal and stimulation of cortical areas, thus a better effortful control. The intact BIS should give them the efficiency to regulate their motivation and a better ability to resist avoidance. For this reason, in the present study, a lower BIS level is expected to predict a higher rate of avoiding mental effort among children with ADHD.

In sum, considering the previous reports, within the first hypothesis, it is predicted that the BIS should mediate the relationship between response inhibition performance and the rate of avoiding mental effort among children with ADHD (see Figure 1). Poorer response inhibition should be related to experiencing a higher difficulty in a cognitive task and producing a higher avoidance motivation; hence, it should predict a higher rate of effort avoidance. On the other hand, the BIS should mediate this relationship because it is the mechanism to counteract the avoidance motivation. However, a hypoactive BIS should be unsuccessful in effectively inhibiting avoidance motivation and thus fail to produce an effective resistance. For this reason, in the case of a challenging cognitive task, children with poorer response inhibition and lower ability to resist avoidance motivation should have a higher rate of effort avoidance.

The rationale for a moderation effect: The unique relationship between the response inhibition and the BIS

Electrophysiological and behavioral measures have been used to investigate the link between response inhibition and the BIS. Studies that focused on the neural signature of the BIS using EEG measures have reported that the P300 amplitude reflects the BIS activity level (Lange et al., 2012; Sadeghi et al., 2019). Findings in the literature suggest that response inhibition and the BIS are linked among children with ADHD, while not among TD children. Notably, one study found no relationship between response inhibition and the BIS among non-patient individuals (Amodio et al., 2008). On the other hand, a more recent study reported a significant relationship between these variables among children with ADHD (Wiersema & Roeyers, 2009).

Amodio et al. (2008) investigated the relationship between response inhibition and BIS among healthy adults. Results showed that there was no significant correlation between the neural signature of the BIS and response inhibition performance ($r = .08$, $p > .05$). Furthermore, behavioral analyses revealed that self-reported BIS activity scores and the response inhibition scores were not significantly related either ($r = -.14$; $p > .05$). These results suggest that behavioral output of the response inhibition and the self-reported BIS are not associated among non-patient adults. Similar results can be expected to be obtained from TD children.

On the other hand, Wiersema and Roeyers (2009) reported that when compared to controls, children with ADHD obtained lower response inhibition scores and had smaller P300 amplitude. Notably, these results demonstrate a positive correlation between the neural signature of the BIS and the behavioral measure of response inhibition. When taken together, these findings raise the possibility that behavioral outputs of the response inhibition and the BIS may be related among children with ADHD while not among TD children. Existing findings imply a unique relationship between response inhibition and the ability to resist avoidance motivation in the child ADHD population.

No study has investigated the relationship between self-reported levels of resisting avoidance motivation and the behavioral output of the response inhibition in the child ADHD population. However, both variables have been reported to be lower in separate studies when compared to non-ADHD groups. The existing evidence in the literature suggests that behavioral measures of response inhibition and the ability to resist avoidance motivation should be positively correlated only among children with ADHD. Considering the studies above, the diagnosis status is predicted to moderate the relationship between response inhibition and resisting avoidance motivation within the second hypothesis. In other words, the indirect effect of response inhibition on effort avoidance through the ability to resist avoidance motivation should be contingent on the ADHD diagnosis.

A new method for measuring frequency of avoidance

The unwillingness to do a task again because of previously experienced discomfort can be identified as avoiding mental effort behavior. No study in the literature has clearly defined this concept with an intention to quantify it. Previously, Hsu et al. (2017) investigated whether non-patient participants with more ADHD symptoms find a cognitive task more taxing and uncomfortable. The authors reported that a higher rate of ADHD symptoms was related to exerting higher mental effort and experiencing higher discomfort.

In this study, participants completed the Paced Auditory Serial Addition Test. They went through 5 runs, and each run included a varying number of blocks. The participants were asked to rate their effort after a specific number of trials in each run. This means the authors focused on one mental capacity (i.e., working memory) and measured the difficulty experienced with a single cognitive task. Using a single task with varying difficulty levels is a plausible design for measuring the experienced subjective difficulty. However, using a multi-domain approach is more appropriate if the aim is to quantify avoidance behavior objectively.

Using several tests consecutively for assessing multiple cognitive domains can provide a more objective measure of avoiding mental effort. ADHD has been reported to be a heterogeneous condition (Willcutt et al., 2005), meaning that the type and severity of cognitive impairments could differ from one child to another. If multiple tests are administered, it may be expected that some of the obtained scores of a child will be below or above average. Based on the evidence in the literature, it may be predicted that if a child finds a task effortful, they will tend to avoid it. That is why using some tests that tax cognitive functions from different domains can set the occasion for avoidance behavior to occur. Asking how difficult a test was after its completion and then looking at how many times an individual avoided a related cognitive domain can better allow the quantification of avoidance behavior.

Table 1. Participant characteristics.

	Clinical ($N = 40$)		Non-clinical ($N = 40$)			
	M	SD	M	SD	t(df)	χ^2
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]	
		Percentage (%)		Percentage (%)		
Higher edu.: father		35		80		21.07*
Higher edu.: mother		25		50		9.30*
Income over 2000€ (high income)		20		30		5.51

Note. [a]Equal variances assumed, because Levene's test for equality >0.05. *$p < .05$. edu. = education.

Method

Participants

The clinical group comprised forty primary school children (30 males, 10 females, Mage = 8.92 years, age range: 7–11 years) living in Cyprus. They were recruited in the Burhan Nalbantoglu Hospital's child-psychiatry outpatient unit, and all were drug naïve. The consecutive sampling method was used for recruiting children into the clinical group. Inclusion criteria comprised ADHD diagnosis and being a Turkish language speaker. Exclusion criteria comprised 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. Children were paid 50 Turkish liras (approximately 10 Euros) for participation at the session's end.

For the non-clinical group, 40 children (30 males; 10 females; Mage = 9.05 years, age range: 7–11 years) were recruited from a primary school in Nicosia, Cyprus. The mean ages of children in the clinical and the control groups were not significantly different from each other, t (78) = −0.48, $p > .05$ (see Table 1 for demographic information). The selection of participants was carried out using an anonymous list. The list included only student number, age, and gender, and it comprised the students for whom parents permitted participation. Children were recruited based on the age and gender distribution in the clinical group. The aim of having such a strategy was to match the two groups on these variables. The inclusion criteria were having the parent's consent and being a Turkish language speaker. Exclusion criteria were having an estimated IQ below 80 and having a neurological or psychiatric diagnosis, which could affect the test results.

Ethical approval was obtained from the ethics review board of the City, University of London (approval number: Psyeth R/F 1718 02). The data collection part of the study was completed in six months.

Instruments

Cognitive effort avoidance measure

The Cognitive Effort Avoidance Measure was produced to quantify the amount of avoidance behavior. In this procedure, nine previously validated, well-known cognitive tests were used with the addition of two novel forms to obtain an avoidance score. This effort was due to the lack of an instrument in the literature that uses neurocognitive tests from different domains. Avoiding mental effort can be described as disliking or not being willing to tackle tasks that put weight on cognitive capacities. Based on this definition, the Cognitive Effort Avoidance Measure employed nine neurocognitive tests, and the addition of two forms (i.e., the display and the face form) allowed the participant to avoid a specific cognitive domain. This design permitted the test administrator to observe the instances when a participant expressed avoidance behavior after experiencing difficulty in a particular cognitive domain. The first one of the forms was an A4 size display, and it included nine removable cards on it (i.e., the display; see Figure 2).

The second form was an A4 size paper that included nine rows of faces. Each row had five faces ranging from very sad to pleased, with a neutral face in the middle (i.e., the face form; see Figure 3).

Figure 2. Cognitive effort avoidance measure: the display.

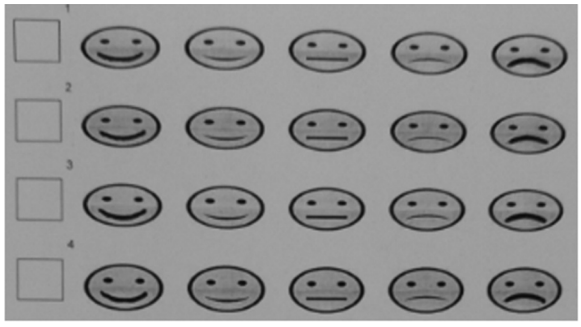

Figure 3. Cognitive effort avoidance measure: the face form.

The aim of adding the first form (i.e., the display) was to present the cards in the categories and allow children to pick a card of their own choice. The display is a laminated A4 size paper (297 × 420 mm), and throughout the session, it remained on the table in a fixed position. It had three columns with different colors, with three cards placed vertically. Each card had a code at the back composed of a number and a letter for showing the corresponding test (e.g., 1A). The tests' names and order are presented in Table 2, and this is how they are presented at the beginning of a session. As the session progressed, the cards were removed from the display and moved out of sight of the participant. Using the Cognitive Effort Avoidance Measure was a three-step process. First, a participant took a card from the display. Second, they completed a test, and third, they circled out a face in the face form. Instructions were as follows:

> You can take any one of the cards you want. Depending on the card you picked, you will receive a test. After completing the test, you will circle a face in the face form. You should choose a face that best reflects how much difficulty you experienced in the test completed. If it was easy, you should circle out one of the smiling faces, but if you had difficulty, you should circle out one of the frowning faces. Please note that the tests in the same column are more similar to each other when compared to the tests in the other columns.

Informing participants about the similarity of the tests in the same column was critical. The rationale for this measure is as follows: if a child has trouble with a test, they will avoid the section to which it belongs and pick a less similar test from a different section. On the other hand, if a participant experiences no difficulty, they should not hesitate to choose a test from the same section. Based on this rationale, experiencing some difficulty with a test and selecting the next one from a different domain was identified as avoidance behavior. The obtained output score was the frequency of avoidance behavior. Each observed avoidance behavior was recorded as 1 point and summed up at the end. The score that can be obtained varies between 0 and 7. Detailed scoring instructions for CEAM are presented in the Appendix.

Detailed descriptions of the cognitive tests used within the Cognitive Effort Avoidance Measure and the instructions for scoring are presented in the supplementary material.

Turkish version of the reinforcement sensitivity theory–personality questionnaire –children

Turkish version of the Reinforcement Sensitivity Theory – Personality Questionnaire- Children (RST-PQ-C) was used to assess the ability to resist avoidance motivation. The RST-PQ-C is a short self-report questionnaire based on the rRST. The RST-PQ-C was translated into Turkish by Bahtiyar et al. (2019). This instrument includes 21 items and three subscales (i.e., BAS, BIS, and FFFS). The McDonald's Omega values for these scales were .85, .65, and .73, respectively. The following statement is an example item from the FFFS scale, "I would be frozen to the spot if there was a snake or spider in the bathroom with me." The following statement is an example item from the BIS scale, "I am careful when doing something that might hurt me." An example item from the BAS scale is, "I am training to be better at sports/things I like doing." Items are rated on a 4-point Likert scale (0 = "never" to 3 = "always"), with a possible score ranging from 0 to 21 on each subscale. A higher score indicates a higher level of activation and sensitivity in a system. In the present study, the BIS scale's total score was used to measure the ability to resist avoidance motivation.

Go/no-go task

The Go/No-go Task was a variation of the Sternberg Memory Task (Sternberg, 1975). The version modified

Table 2. Names and the order of the tests in the cognitive effort avoidance measure.

	1	2	3
A	Auditory Continuous Performance Test (Rosvold et al., 1956)	Working Memory- Switch Task (Sternberg, 1975)	Wisconsin Card Sorting Test (Grant & Berg, 1948)
B	Bourdon-Vos Test (Vos, 1998)	Corsi Block Tapping Test (Corsi, 1972)	WISC-4 Matrix Reasoning subtest (Wechsler, 2011)
C	WISC-4 Vocabulary subtest (Wechsler, 2011)	Go-no/go Test (Sternberg, 1975)	Choice Delay Task (Sonuga-Barke et al., 1992)

by Hester and Garavan (2005) was used. In the present study, some modifications were made regarding the number of runs and trials to make this measure appropriate for children. The E-Prime Version 2.0 computer program presented the stimuli in the 50-point Arial font on a Windows XP computer with a 17-inch color monitor. First, participants received a short practice session. They were given a letter (i.e., x) and instructed to press the keyboard key "space bar" for all the letters on the screen but to withhold their response when the "x" appeared. Then, the actual test run started. Children were given four letters (i.e., a memory list) to remember. These letters (i.e., L, U, A, and N) were presented for six seconds- in white color on a black background- and then immediately followed by a black screen and a rehearsal period of 6 seconds. Participants were instructed to rehearse these letters and press the keyboard key' space bar' for any letters on the screen but withhold their response if one of the letters from the memory list 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. The following score was recorded from the keyboard input: number of accurately inhibited responses (i.e., total correct).

Procedure

Data from the clinical group were collected in the Burhan Nalbantoglu Hospital's child-psychiatry outpatient clinic. The diagnostic process involved a multi-step approach. In the first session, information about medical and neurodevelopmental history was collected by a trained psychiatrist. If ADHD was suspected, then Conner's parent's and teacher's forms were given to be returned in the following meeting. In the second session, all the collected information was considered together in light of DSM-5 diagnostic criteria. When the psychiatrist confirmed the ADHD diagnosis, the parents and the children were informed about the present study and offered a chance to take place. The opt-in sampling strategy was used. Participation was voluntary, and if the family and the child were willing to participate, they participated in the study.

Initially, the parents and the children filled out and signed an informed consent form. Then, the parents were given a demographic information form, and the children were given the Turkish version of the RST-PQ -C to complete. The child was seated in front of a table. A computer, a mouse, a pen and the Cognitive Effort Avoidance Measure were on the table. Participants were instructed to choose a card from the Cognitive Effort Avoidance Measure's display and then read the number and the letter at the back of the card. Afterwards, they were given the corresponding test to complete according to the instructions. Later, they circled out a face in the face form, which continued until they circled out the last face in the form. Each child had only one session during the data collection, and each testing session took one and a half hours.

Data from the non-clinical group were collected from a primary school in Nicosia, Cyprus. The data collection process from the non-clinical group was entirely similar to how the data was collected in the clinical group. The same computer, mouse, test materials, and questionnaires were used. The lead author of the present study carried out the sessions. Data collection with each child took one and a half hours. Each child went through only one session.

Data analytic strategy

Initially, the data were analyzed using IBM SPSS Statistics 24 for Windows. Descriptive statistics were computed. An independent samples t-test was performed to compare groups with and without ADHD regarding their response inhibition performance, the ability to resist avoidance motivation, and the frequency of avoiding mental effort. Then, the Pearson correlation coefficients were computed to investigate the relationships between response inhibition, resisting avoidance motivation, and the frequency of avoiding mental effort. Moreover, a simple mediation model of the relationships between response inhibition and the frequency of avoiding mental effort through the ability to resist avoidance motivation (H1) was tested with the PROCESS model 4 (Hayes, 2013). A moderated mediation analysis was run using PROCESS model 7 to assess if the diagnosis status moderated the proposed mediation model. This analysis was employed for testing the second hypothesis, which stated that the indirect effect of the response inhibition on the frequency of avoidance through resisting avoidance motivation should be a function of ADHD diagnosis (see Figure 4 for statistical model). In this model, the independent variable is the response inhibition performance, and the dependent variable is the frequency of avoiding mental effort. The mediator variable is the self-reported ability to resist avoidance motivation, and the moderator is the diagnostic status.

Results

Group differences and zero-order correlations

In the first set of analyses, an independent samples t-test was used to compare the group differences in

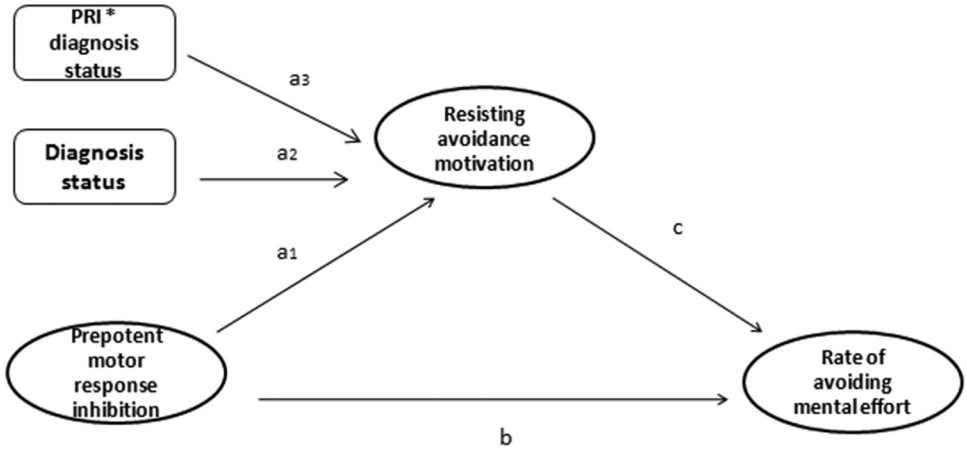

Figure 4. Statistical model showing the conditional indirect effect of the prepotent response inhibition on the frequency of avoidance behavior through the ability to resist avoidance motivation. PRI = prepotent motor response inhibition.

response inhibition, resisting avoidance motivation, and avoiding mental effort. The two groups statistically significantly differed in the response inhibition performance, the ability to resist avoidance motivation and the frequency of avoidance behavior. Children with ADHD obtained lower response inhibition and resisting avoidance motivation scores. However, their rate of avoiding mental effort was higher when compared to the non-clinical group (see Table 3 for a comparison of values).

Group differences regarding the experienced task difficulty (i.e., circling sad faces in the face form) were investigated using independent samples t-test. This analysis showed that groups differed significantly, $t\ (78) = 7.92$, $p = .001$, Cohen's $d = 1.84$. Children in the clinical group circled more sad faces ($M = 4.33$, $SD = 2.10$) compared to the non-clinical group ($M = 1.05$, $SD = 1.5$).

In the second set of analyses, Pearson correlation coefficients were computed to investigate the relationships between the variables of interest (see Table 4). In the clinical group, statistically significant relationships were obtained between the variables. There was a modest positive correlation between response inhibition performance and the ability to resist avoidance motivation. Furthermore, response inhibition performance had a modest negative correlation with avoiding mental effort. The ability to resist avoidance motivation was also negatively and moderately correlated with avoiding mental effort. On the other hand, in the non-

Table 3. Descriptive and inferential statistics of prepotent response inhibition scores, resisting avoidance motivation scores and cognitive effort avoidance measure scores in ADHD and non-clinical groups.

	ADHD ($N = 40$)		Non-clinical ($N = 40$)			
Measure	M	SD	M	SD	t (df)	d
PRI	7.08	2.42	10.18	3.14	−4.95(78)*[a]	1.11
BIS	10.13	5.17	13.75	3.83	−3.56(78)*	0.80
AME	2.78	1.46	0.60	0.95	7.89(78)*	1.84

Note. $p < .01$; [a]Equal variances assumed because Levene's test for equality >.05; d = Cohen's d; PRI = Prepotent motor response inhibition; BIS = Resisting avoidance motivation; AME = Rate of avoiding mental effort.

Table 4. Zero-order correlations between variables in the whole sample, ADHD group and non-clinical group.

	The whole sample			ADHD group			Non-clinical group		
Measures	1	2	3	1	2	3	1	2	3
1. PRI	-	.25*	−.50**	-	.36*	−.33*	-	−.19	−.25
2. BIS		-	−.52**		-	−.54**		-	−.09
3. AME			-			-			-

*$p < .05$; **$p < .01$; PRI = Prepotent motor response inhibition; BIS = Resisting avoidance motivation; AME = Rate of avoiding mental effort.

clinical group, relationships between response inhibition scores, resisting avoidance motivation scores, and effort-avoidance scores did not reach statistical significance.

Pearson's correlation was also used to investigate the relationship between response inhibition performance and self-reported task difficulty. A significant negative correlation coefficient was obtained ($r = 3.7$, $p < .05$).

Mediation analyses

The results of the mediation analyses were summarized in Table 5 for the clinical group. This analysis was not run for the non-clinical group because no correlations between variables were significant. The paths a, b, and c (i.e., total effect) were significant in the clinical group. The confidence interval for the indirect effect did not contain zero, showing that the effect of the response inhibition on avoiding mental effort was mediated by the ability to resist avoidance motivation. Obtaining a significant mediation effect supported the first hypothesis. Furthermore, when controlling for the mediator, response inhibition performance was no longer a significant predictor of frequency of avoidance (direct effect: path c'), $\beta = -.09$, t (37) = −1, 06, $p = .29$. This indicated a complete mediation of the ability to resist avoidance motivation, in the relationship between response inhibition performance and the frequency of avoiding mental effort.

Moderated mediation analysis

The conditional indirect effect of response inhibition was tested using the moderated mediation analysis with 5000 bootstrapped samples. Table 6 shows the model's results, using diagnosis status as a moderator. All the paths were significant along with the a3, which indicated the existence of an interaction between the diagnosis status and the response inhibition performance. This provided evidence that the diagnostic status moderated the path between response inhibition and the ability to resist avoidance motivation. The index of moderated mediation was above zero (index of moderated mediation = 0.14, SE = 0.06, Boot LLCI = 0.02, Boot ULCI = 0.26), confirming the hypothesized conditional indirect effect. In other words, the diagnosis status moderated the first stage of the mediation model (i.e., a1).

Results revealed that the response inhibition had an indirect effect on the frequency of avoidance through resisting avoidance motivation in the

Table 5. Standardised results of the regression-based mediation model showing the indirect effect of the PRI on avoiding mental effort through resisting avoidance motivation in the clinical group.

	BIS	AME
PRI	**.36****	**−.33***
BIS		**−.49****
R^2	.12	.32
F(df1, df2)	5.57**(1, 38)	45.21**(2, 37)

Standardized indirect effect

Predictor	mediator	criterion	Effect	BootLLCI	BootULCI
PRI	BIS	AME	−.17	−.38	−.02
Direct effect of PRI on AME			−.09	−.27	.08
Total effect of PRI on AME			−.20	−.38	.01

Note. PRI = Prepotent motor response inhibition; BIS = The ability to resist avoidance motivation; AME = Rate of avoiding mental effort.
*$p < .05$; **$p < .01$.

Table 6. Ordinary least squares regression coefficients for the conditional indirect effect of the PRI on avoiding mental effort through resisting avoidance motivation, with group membership as moderator.

Outcome→		BIS			Avoiding mental effort	
Predictor	Path	Coeff	SE	Path	Coeff	SE
intercept		−6.69	4.94		5.16*	0.48
PRI	a_1	1.76*	0.62	c	−0.21*	0.05
BIS	-	-	-	b	−0.14*	0.03
Group	a_2	11.42*	3.22	-	-	-
PRI x Group	a_3	−0.99*	0.37	-	-	-
		$R^2 = .22$			$R^2 = .42$	
		F (3,76) = 7.23*			F (2,77) = 28.29*	

Note. Coeff = unstandardized regression coefficients; SE = standard error; PRI = prepotent response inhibition; BIS = the ability to resist avoidance motivation; coefficients with asterisks are significant 95% confidence level.

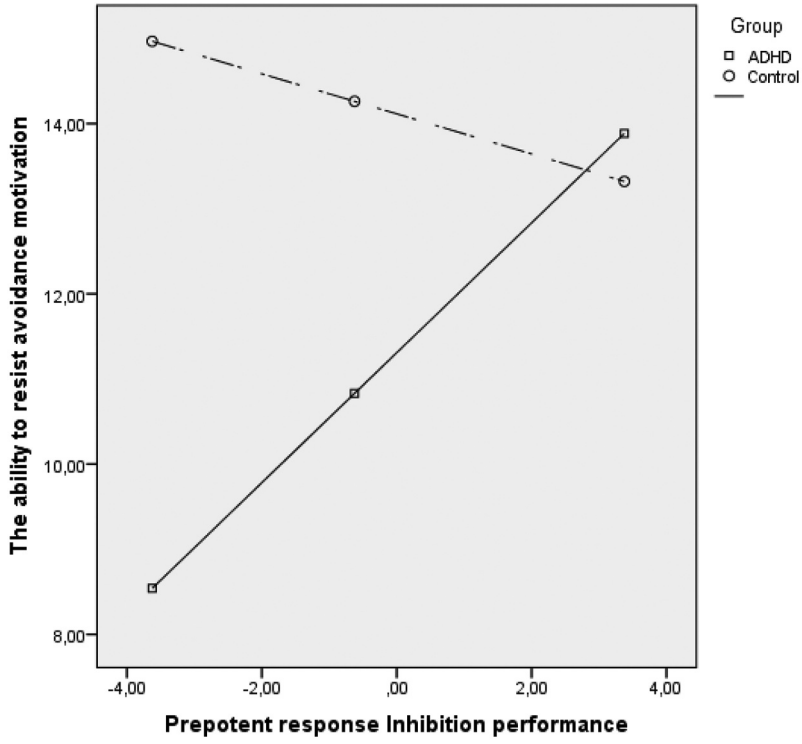

Figure 5. Interaction between the prepotent response inhibition and the diagnosis status in predicting the ability to resist avoidance motivation.

clinical group (effect = −0.11, SE = 0.05, Boot LLCI = −0.22, Boot ULCI = −0.01). However, the non-clinical group had no such effect (effect = 0.03, SE = 0.03, Boot LLCI = −0.02, Boot ULCI = 0.08). A visual representation of the interaction between the response inhibition performance and the diagnostic status in predicting the ability to resist avoidance motivation is presented in Figure 5. The figure plots that a lower level of response inhibition performance predicts a lower level of resisting avoidance motivation only in the presence of an ADHD diagnosis. On the other hand, when the ADHD diagnosis is not present, even at the lower levels of response inhibition performance, the ability to resist avoidance motivation appears optimal. This suggests an independent functioning of the response inhibition and the ability to resist avoidance motivation in the non-clinical group.

Discussion

DSM-5 states that children with ADHD strongly dislike and try to avoid tasks that require sustained mental effort. The present study investigated the role of the response inhibition performance and the ability to resist avoidance motivation in avoiding mental effort. The aim was to test a moderated mediation model to show the conditional indirect effect of response inhibition on the avoidance rate through the ability to resist avoidance motivation. Findings supported the hypotheses. It is demonstrated that the indirect effect of response inhibition on the rate of avoidance through resisting avoidance motivation was moderated by the diagnosis status.

Children with ADHD avoid mental effort more frequently than their typically developing peers

Initially, the levels of response inhibition, resisting avoidance motivation, and avoiding mental effort were compared between the groups. Findings supported the proposition of the DSM-5 that children with ADHD avoid tasks that require mental effort more frequently than TD children. Empirical evidence for this proposition is provided using an objective measure that includes multiple tests that tax various mental capacities.

As expected, the response inhibition performance was poorer in the clinical group. This finding was in line with the previous study results in the literature (Scheres et al., 2004; Slusarek et al., 2001). Moreover, the ability to resist avoidance motivation was also lower among children with ADHD, which was in line with the suggestions of the previous studies (Iaboni et al., 1997; Quay, 1997; Sadeghi et al., 2019).

The obtained correlations were in the expected direction. In the clinical group, the response inhibition performance and the ability to resist avoidance motivation were negatively related to the avoidance rate. This finding shows that lower scores in response inhibition and resisting avoidance motivation are related to more frequently avoiding mental effort. The largest correlation value was obtained between the ability to resist avoidance motivation and the avoidance rate ($r = -.54$, $p = .001$). On the other hand, none of these variables was significantly correlated in the non-clinical group. Obtaining significant correlations in the clinical group but not the non-clinical group suggests mental processes unique to the child ADHD population.

Mediating role of resisting avoidance motivation among children with ADHD

In the present study, it is found that poorer response inhibition predicts a higher avoidance rate. This finding can be better interpreted if two additional results of the present study are considered. First, there is a significant negative correlation between response inhibition and self-reported task difficulty ($r = -3.7$, $p < .05$). This finding supports that lower response inhibition is related to experiencing greater difficulty in cognitive tasks. Second, children with ADHD find cognitive tasks more difficult when compared to their TD peers. Together, these findings support that poorer response inhibition and experiencing higher task difficulty led to a higher avoidance motivation and a higher avoidance rate.

Previously, scientists speculated that poor ability to resist avoidance motivation could lead to self-control failure and unregulated withdrawal behaviors (Findley, 2014; Gable et al., 2018). The present study's results support this notion by demonstrating that a poorer ability to resist avoidance motivation predicts a higher avoidance rate. Based on the present findings, it can be argued that due to poor response inhibition, children with ADHD perceive tasks as more difficult, and this can increase the FFFS activity and avoidance motivation. Results suggest that the hypoactive BIS cannot efficiently regulate the FFFS, leading to a higher avoidance rate.

When the ability to resist avoidance motivation is controlled, the relationship between response inhibition and avoidance rate becomes nonsignificant. This presents a complete mediation. These findings support the first hypothesis and emphasize the critical role of resisting avoidance motivation in the appearance of avoidance behavior. It should be noted that the cross-sectional nature of the study prevents making any cause-effect conclusions. However, the present results make investigating the significant predictive link between response inhibition and the ability to resist avoidance motivation intriguing in a future experimental study.

Evidence in the literature shows that inhibiting a prepotent response devaluates the stimuli that triggered the response. For example, Ferrey et al. (2012) showed that inhibiting sexual stimuli embedded in the Go/no-go Task results in the devaluation of the sexual stimuli. Moreover, Houben et al. (2011) showed that inhibiting alcohol-related stimuli increases negative attitudes toward alcohol and decreases alcohol consumption. These findings further support a link between response inhibition and motivation regulation. These results suggest a BIS involvement and underscore the need to investigate further the link between response inhibition and the ability to resist avoidance motivation.

Moderating role of diagnosis status

Moderated mediation analysis results showed that the indirect effect of response inhibition on the avoidance rate through resisting avoidance motivation was moderated by diagnosis status. The moderated mediation hypothesis was confirmed (hypothesis two). Specifically, path a (response inhibition → resisting avoidance motivation) was moderated by diagnosis status. This finding shows that the mediation mechanism exists only among children with ADHD but not among TD children.

An important question here is why the proposed mechanism exists in the ADHD group but does not exist among TD children. Evidence in the literature shows that response inhibition and resisting avoidance motivation are not related among healthy adults (Amodio et al., 2008). The present study further adds that behavioral measures of response inhibition and resisting avoidance motivation are also nonsignificant among TD children. On the other hand, Wiersema and Roeyers's (2009) study demonstrates a positive correlation between the behavioral output of response inhibition and the P300 amplitude (i.e., EEG output for resisting avoidance motivation) only among children with ADHD. The present study further adds that the behavioral outputs of response inhibition and resisting avoidance motivation are positively related only among children with ADHD. This relationship does not exist among TD children and seems to be a unique feature of ADHD pathology.

The positive correlation between response inhibition and resisting avoidance motivation may be explained by the global strength of the inhibition network to which

they belong. The literature includes ample evidence to support that inhibition ability relies on a system with interacting components (Zhang et al., 2017). There is an agreement among researchers that inhibition is mediated through an interacting, spatially distributed multi-component neural network. Study findings demonstrate that inhibition consistently activates the supplementary motor area, inferior prefrontal cortex, anterior cingulate, and basal ganglia (Hung et al., 2018).

It can be argued that response inhibition and the ability to resist avoidance motivation are two components of this network. The network's strength could be reflected in the strength of its components. For this reason, the strength of response inhibition and resisting avoidance motivation could depend on the global strength of the inhibition network. It can be speculated that TD children could have their separate inhibition abilities at different strengths. However, it seems that children with ADHD have a widespread impairment in the inhibition network. It appears that children with ADHD with poorer response inhibition also have a poorer ability to resist avoidance motivation. The present study's findings underscore the need for further research to clarify interactions of the components of the inhibition network among children with ADHD.

Based on the present results, it can be argued that, at a group level, children with ADHD have poorer response inhibition and a higher avoidance motivation when faced with challenging cognitive tasks. Unfortunately, because these children have a weaker ability to resist avoidance motivation, they cannot sufficiently inhibit it; therefore, they cannot persist on a cognitive task but frequently avoid it.

Theoretical implications

The present study advances our knowledge about the role of response inhibition and the ability to resist avoidance motivation in childhood psychopathology. The inhibition theory of ADHD proposes that inhibition impairment underlies symptoms of ADHD (Hwang et al., 2019). The present study provides evidence that impaired response inhibition contributes to frequently avoiding mental effort. However, the ability to resist avoidance motivation also appears to be critical in the process. Further investigation of the unique link between these variables can provide us with a better insight into the inhibition-related pathology among children with ADHD.

The relationship between performance tests and rating scales attracted significant attention. Studies in the literature show that there can be a weak correlation between a neuropsychological test and a self-report rating scale, although they aim to measure the same construct (e.g., executive functioning; Toplak et al., 2013). Impairments in ADHD have been proposed to be related to different levels of brain functioning. Present study findings demonstrate that using a performance test and a rating scale can be valuable for studying a specific symptom (i.e., avoiding mental effort) that could stem from different levels of functioning. In the present study, using the Go/No-go Task (i.e., a cognitive and objective measure of response inhibition) and the BIS scale (i.e., a self-report measure of resistance to avoidance motivation) provided input from two separate but interacting inhibitory constructs ($r = .36$). Moreover, both variables were able to predict the rate of avoiding mental effort. For this reason, findings demonstrate the usefulness of using objective performance tests and self-report rating scales simultaneously for investigating specific impairments in ADHD, although they assess different levels of functioning.

Clinical implications

Parents of children with ADHD often complain that their children do not want to do homework, experience difficulty in engaging with tasks that require mental effort and leave the tasks uncompleted. Avoiding mental effort has been demonstrated to be an impairing behavior in terms of academic achievement (Zoromski et al., 2021) and self-confidence (Harpin et al., 2013) among children with ADHD. The present study provides empirical support for its frequent expression in ADHD and shows that response inhibition and resisting avoidance motivation play a crucial role in its appearance.

Findings suggest that children with ADHD have less capacity to resist avoidance motivation that is produced by irritating stimuli. A question can be asked: What can be done to support the ability to resist avoidance motivation among these children when faced with challenging cognitive work? A task could be made more compelling by decreasing its difficulty level. This could reduce the rRST – FFFS activation and the amount of avoidance motivation that this system produces. Moreover, adding an external reward to the task would stimulate the rRST- BAS and increase the approach motivation toward the task.

The findings also point to the response inhibition performance as a potential target for reducing the amount of avoidance. Cognitive training, targeted to enhance the response inhibition ability, could effectively reduce the frequency of avoidance.

Limitations and future directions

One limitation of the present study is that its cross-sectional design does not allow causal interpretations. The only way to establish a causal relationship between variables is through an experimental design. However, the experiment cannot be conducted in this case because we cannot manipulate response inhibition performance or ADHD diagnosis. However, having a quasi-experimental design allowed a natural observation of the variables at different levels in the clinical and control groups.

It has been reported that procrastination is more often encountered among adults with ADHD than non-patient individuals. It can be interesting to investigate if the lower levels of response inhibition and resisting avoidance motivation remain into adulthood and contribute to procrastination.

One similar concept to avoiding mental effort is cogniphobia, and it has been defined as the avoidance of mental effort exertion on tasks perceived to be cognitively demanding. This phenomenon has been explained to appear due to a fear of developing a headache, and it has been demonstrated that it can contribute to poor cognitive test performance (Silverberg et al., 2017) and invalid scores on performance validity testing (Lee et al., 2021). There are studies in the literature showing that headache is more common among children with ADHD compared to non-clinical samples (Mahajnah et al., 2020). Previous study results suggest that a combination of ADHD and headache leads to poorer academic functioning, more sleep problems and overall lower quality of life (Paolino et al., 2015). However, no study investigated the relationship between exerting mental effort and experiencing a headache among children with ADHD. For this reason, in a future study, it can be worthwhile to investigate the role of cogniphobia in avoiding mental effort among children with ADHD.

Studies in the literature demonstrated that the cognitive scores of children with ADHD fluctuate over time. In this context, an intriguing question is whether we can expect performance variability in the factors investigated in the present study. For example, intra-individual variability in the response inhibition performance has been reported for children with ADHD (Vaurio et al., 2009). However, inhibition impairment has also been claimed to be a stable feature of ADHD, and it is proposed to be a phenotype marker for genetic analyses (Crosbie et al., 2013). For this reason, a drastic increase may not be expected in an individual's inhibition performance at two different times.

On the other hand, findings in the literature suggest that the level of resisting avoidance motivation may be relatively stable across developmental stages among TD children (Windsor et al., 2012). However, there is no study to show the level of resisting avoidance motivation across different developmental periods among children with ADHD. It can be worthwhile to carry out such a study in the future to investigate the relationship between the ability to resist avoidance motivation and the reported performance fluctuations among children with ADHD.

Regarding the intra-individual stability of effort avoidance measure, in the present study, multiple tests that assess different domains were used for measuring the level of effort avoidance. It can be argued that multiple tests could ensure that even if a child fluctuates in a particular cognitive domain, the performance in the rest of the domains could remain the same. For this reason, the Cognitive Effort Avoidance Measure has a good potential to appear reliable in a re-assessment of the level of effort avoidance. Using the Cognitive Effort Avoidance Measure within a future study can be helpful in obtaining an effort avoidance score as well as some reliability evidence for this measure.

Finally, response inhibition and the ability to resist avoidance motivation accounted for 32% of the variance; hence, other factors play a role in avoiding mental effort. Future studies can include instruments for measuring levels of factors that could influence avoiding mental effort, such as self-confidence, personality traits, and impulsivity. This can help to underpin some other factors that contribute to this problem.

Conclusion

Avoiding mental effort is a symptom of ADHD that results in academic underachievement. The present study links the poorer response inhibition and resisting avoidance motivation to these children's observed higher avoidance rate. The findings support the proposed neuropsychological mechanism for explaining frequently avoiding mental effort.

Moderated mediation analysis findings demonstrate that the ability to resist avoidance motivation completely mediates the relationship between response inhibition and avoidance rate only among children with ADHD. The present results suggest that poorer response inhibition led to a higher avoidance motivation, which cannot be efficiently regulated due to an impairment in the ability to resist avoidance motivation among children with ADHD. On the other hand, intact

resistance ability seems to provide TD children with the means to persist in challenging cognitive tasks.

Finally, the present study informs the clinical practice that interventions to improve response inhibition performance or support the rRST – BAS activation can help reduce the avoidance rate among children with ADHD.

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Ethics approval

Approval was obtained from the ethics committee of City, University of London and Near East University. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Consent

Informed consent was obtained from all participants included in the study and their legal guardians.

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